# THE ASIATIC LION: A study of ecology and behaviour

by

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## ABSTRACT

The primary aims of this research were to investigate the ecology and behaviour of the Asiatic lion (Panthera leo persica), and to advise on ways of conserving it. The field research was done between 1968-71 in and around the Gir Forest Wildlife Sanctuary in western India, where the lions are now restricted. The main studies were of the habitat, availa-:bility of wild and domestic prey, food habits based on faecal analysis, lion predation on domestic stock, the inter-relations between lions and people living in the area, lion population dynamics and general behaviour. This research was part of a larger enterprise involving the total ecology of the sanctuary.

Evidence for a decline in lion numbers in the recent past has been largely associated with a decrease outside the sanctuary boundaries, where conditions are now so poor that survival is difficult. Oblique aerial photographs showed that most of the original forest has been cleared, and that the landscape is dominated by cultivation with few prey. The human population is rapidly expanding, and outside the sanctuary little can be done to stabilise or improve conditions for lions, since further land development seems inevitable. For these reasons conservation within the sanctuary is vital.

Here conditions were much better, but there is cause for concern. Less than six percent of the land was culti-:vated, but more was being cleared. Based on sample counts,

an estimated 44,000 domestic stock but only 5600 wild ungulates lived or grazed within the sanctuary. Analysis of lion faeces collected throughout the sanctuary showed that about 75% of the lion's diet was domestic stock, reflecting its great availability. Study of several hundred kills of domestic stock revealed that catching prey and feeding was difficult. At night, lions ate nothing from 41% of domestic animals killed, largely because they were driven away after making kills inside villages. In day time, lions were usually able to eat something, but also lost substantial amounts. More than half of all kills investigated were scavenged by hide collectors. The thesis includes several recommendations to improve the management of the lions while interfering minimally with the ecology of the people.

Five estimates of the lion population size were made, averaging 190 and ranging between 100-250. Three indices of lion abundance were prepared for future use in assessing trends. These easily repeatable methods involved few assumptions and did not depend upon making calculations of the actual population size. A behavioural inventory of the lion is also outlined which reviews postures and attitudes, social interaction within the pride, advertise-
:ment, prey catching and feeding.

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I owe no end of gratitude to the game keepers. After my first week in Gir they had me convinced that they were foolhardy men. Almost every day one or more game keepers had to drive lions off a kill to retrieve the 'expensive' rope with which the bait had been tethered. On innumerable occasions they intercepted lions which threatened, or were in the midst of a charge, by simply walking towards lions

in a demonstrative manner. In time they taught me some of their methods, and convinced me that I had misconceived notions and fears about lions. Without their assistance the behavioural section of this thesis would have been without substance.

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# CHAPTER I

# INTRODUCTION

I undertook this study because I was particularly interested in investigating the problems and ways of con-:serving an endangered species. The Asiatic lion was chosen from the International Union of Conservation of Nature and Natural Resources list of rare and endangered species, in consultation with Dr Lee Talbot, Mr Noel Simon and others. It was thought to be a typical example of an endangered mammal because more than half of the recently extinct mammals were predators, and most of these were large (Talbot, 1959). The Asiatic lion was suitable for an intensive study because, although rare, its distribution was concentrated into a single 1300 $km^2$ area in Gujarat state, western India. There had also been repeated requests to have it investigated (Daniel, 1956; Talbot, 1959; Spillet, unpublished report; Indian board for wildlife in 1956).

I examined the ecological factors affecting lion numbers and assessed the size and structure of the lion population. The past trend in numbers was assessed from existing data, while a new base line was established for assessing the future population trends. An ethogram, or behaviour inventory, of the Asiatic lion was also recorded for the first time.

Ecological factors studied included predator-prey relationships, and the pattern of land use within the

lion's environment. Lions were found within the Gir hills and to some extent in the surrounding lowlands. Most of the hills were designated as the Gir Wildlife Sanctuary, and used primarily for domestic grazing, forestry and tourism. The surrounding lowlands were heavily cultivated. I measured the extent of cultivation, and its encroachment upon the sanctuary, which was impor-:tant because neither lions nor their prey could inhabit cultivated lands. Prey consisted of large numbers of domestic bovids and fewer wild ungulates. I measured the size and composition of the prey population, the pattern in which kills were made and the conditions which limited feeding. Prey species eaten by lions was assessed from faecal analysis and from examining herdsmen's losses. A key was made to identify species from hair found in faecal samples.

No exact method was found for assessing the number of lions. Instead, estimates were made using four different methods. Several methods were also used to establish indices of lion abundance. These were rapid and simple to use, and had minimum possibilities for human error. Thus they were suitable for future use for assessing trends.

I studied in detail the structure of two prides and looked briefly at others. I tried to measure population density, social structure, patterns of movement, home ranges and areas of concentrated use. The ethogram was prepared in the course of these investigations. It

included a record of postures and attitudes, social interaction within the pride, advertisement between prides and prey catching.

# CHAPTER 2

# HISTORY

The origin of lions in Eurasia is unknown. Lions were undoubtedly present in Greece, Bulgaria and Mesopotamia during the third to the first millenium B.C. (Dawkins, 1866; Vereshchagin, 1967), and as many works of art dated 1500-2000 B.C. testify in both Greece and Crete (Hemmer, 1965). Some of the tracings of hunting scenes prepared by Hemmer show the distinct 'belly fold', a characteristic of Asiatic lions today rarely found in African lions. In Iran, a royal lion hunt was embossed on a silver plate dating from the third to fourth century A.D. (Ghirshman et al, 1971), and lions occur on so many early works of art from that region as to suggest they were long established. Lion hunting scenes also appear on Indian coins minted between 300-400 A.D., (Bedi, pers. com.)

With the advent of firearms the Asiatic lion was exterminated over most of its range. The many records of hunts reported in the last 200 years provide the only detailed knowledge of the lion's distribution during this period, and those records which I could find have been plotted in figure 1; each dot referring to a separate account when one or many lions were sighted or shot (see Appendix). Based on these records, the Asiatic lion was not as widely distributed in recent times as many authors suspected. It is unlikely that lions existed in the Arabian peninsula, although this region is included in the distribution maps of four authors -- Bartholomew et al, 1911; Guggisberg, 1963; Mazak, 1968 and Talbot, 1959.

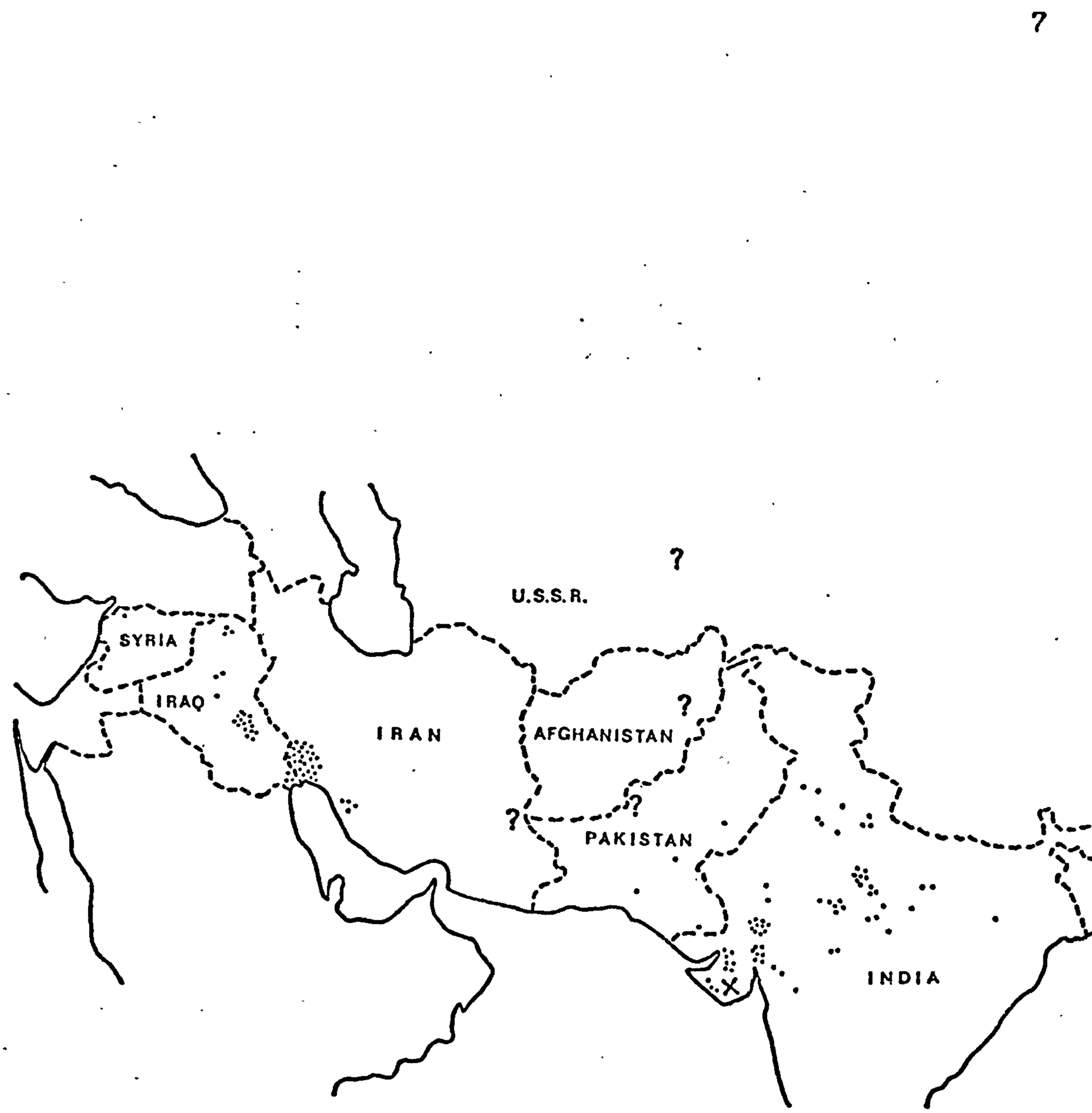



Fig. 1 : Records of lions shot or sighted since 1781

• Firm record

? Questionable record

X Present location

The only evidence I could find to the contrary was a record of a lion seen in a menagerie in Muscat by Sir Wallis Bodge (1920) and again in 1890 by Colonel Burton. However Bodge clearly stated that it had been caught in Iran. After travelling through Yemen, Hugh Scott (1942) wrote that lions possibly lived there until recently, but gave no supporting evidence. Harrison (1968) made no reference to lions in his exhaustive book on Arabian mammals.

Lions were commonly killed or sighted over the entire length of the Tigris and Euphrates rivers in Iraq. In Iran they existed in considerable numbers on the coastal side of the Kuhha - Ye Zagros mountain chain, but appeared no where else. It was Layard's (1887) impression that they did not cross the mountain chain into the valleys of the Persian interior. Wild boar were reportedly abundant where lions existed and possibly were the main prey apart from domestic stock. By the turn of this century, hunting had virtually exterminated the Asiatic lion in the Middle East, although occasional stragglers were seen upto 1942, when a definite sighting was reported near Dezful in southwest Iran.

Evidence of lions in the largely barren interior of Iran, Afghanistan and the western most portions of Pakistan is lacking for the past 200 years. Hamun-e Jaz-Muryan in eastern Iran is regarded as the hottest area in the world for much of the year, while further north there are daily 100 knot per hour (185 km per hour) winds during part of

each year (Harrington, pers. com.) However it cannot be certain that lions did not exist in these regions, for when prey is available, lions are capable of living under exceedingly rigorous conditions (e.g. Kalahari desert). The lack of records in the intervening range between Iran and Pakistan may be because no literate hunters penetrated these regions. Moreover, if lions colonised India from the west, they must have crossed this area.

The lion's distribution was quite extensive across the Indian sub-continent in the past 200 years. Large numbers were found in Rajasthan, Gujarat, Punjab, Uttar Pradesh, and Madhya Pradesh, but not at all in south India, and only once in Bihar and Orissa. No obvious geographical barriers stopped them from occupying these areas, and perhaps they were still extending their range when they were exterminated. By approximately 1884 their range had been reduced to the Gir forest in the Kathiawar peninsula (Pocock, 1936). In 1900, following the Great Kathiawar Famine, the Junagadh Nawab took the first steps towards protecting the lion. However in the following year he complained to the Viceroy of receiving no co-operation from neighbouring states. By 1908, expanding cultivation had divided the Gir forest into three parts (Fenton, 1908). Lions living in the Barda portion to the west of the present sanctuary quickly succumbed to overhunting. Fenton criticised the right given to soldiers to hunt lions, but attributed the lion's continued existence to the substantial

amount of forest still remaining. Its sambar, wild boar, chital, four-horned antelope, nilgai, Indian gazelle, blackbuck (Antilope cervicapra) porcupine and indigenous domestic stock provided a rich food supply for lions, while malaria kept the human population low.

By 1913, the forest boundary was revised because of further encroachment. Wallinger estimated lion numbers at about 20, based on only four animals reported killed by lions in three months (Caldwell, 1938). Another observer reported an even more dismal estimate. These probable underestimates caused the Junagadh Nawab to give rigid protection to lions.

By 1920, the population of Asiatic lions in Gir had increased to at least 100 (Ratangar, 1920). Lions were seen in Mytiala, to the northeast of Gir in Bhavnagar district, the first for many years. Ratangar recommended that up to five lions could be shot per year with no harm to the population. This policy was adopted at least until 1938, while another 8-10 animals were annually killed outside the Nawab of Junagadh's jurisdiction (Caldwell, 1938). Between 1936-1949 more lions were shot than in the previous period (Wynter-Blyth, 1949), but in 1950-1955 very few were taken, hunting being stopped altogether in 1955. This limited cropping apparently had no effect on the lion population. A census of lion tracks held in 1936, 1950 and 1955 resulted in estimates of approxi-:mately 290, 250 and 290 lions respectively (Wynter-Blyth,

1949; Wynter-Blyth, 1956; Dalvi, 1969). Moreover there had been a conspicuous increase in the number of lions found in the Mytiala hills, perhaps as a result of intensive forest protection since the early 1930s (Wynter-Blyth, 1956). A similar count in 1963 showed no change from 1955, but a decline occurred to about 180 in 1968 (Dalvi, 1969). However estimating lion numbers from their tracks was a poor method at best, and too much reliance should not be placed on any of these figures.

Fundamental to the lions continued existence was the preservation of its habitat. In 1965, a 1265 $km^2$ area, encompassing most of the Gir forest, was declared a wildlife sanctuary. The forest had been a reserve for many years, but this new act strengthened the resistance against further encroachment.

# CHAPTER 3

# THE GIR STUDY AREA

The Gir forest lies in the centre of Kathiawar peninsula, India at 20.5-22.6°N lat. and 70-72°E long., an area in which the Gir hills, a low range of volcanic origin, varying from 429-1925 feet (131-587 m) above sea level (Joshi et al, 1953), are surrounded by flat, arid agricultural lands (fig.2). Six rivers are perennial, the remainder carrying water only in the monsoon. Soils range from lateritic soil in much of the north and east of the area to black cotton soil in the southwest and along many of the valley floors; agriculture predomina-:ting in areas of black cotton soil. The climate is strongly monsoonal, with winds from the Arabian Sea bringing wet weather between June and September. Amounts of precipitation are however small, with c 64cm being typical of the Gir as a whole. The monsoon is followed by dry cool weather which extends to February, to be followed by a hot season with desiccating north winds. The average maximum and minimum temperatures at Gir varies from 16° to 37° C (Joshi et al, 1953).

Approximately two thirds of the forest, mostly in the west, is dry mixed deciduous, dominated by teak (Tectona grandis) in the upper storey, and intensively managed on a 40 year rotation. The understorey is sparse, but includes shrubs such as Carissa carandas and Helicteres isera. The eastern portion of the sanctuary is a rolling Acacia savanna, with Anogesius latifolia replacing teak (Berwick, unpub. report). At intervals the area is

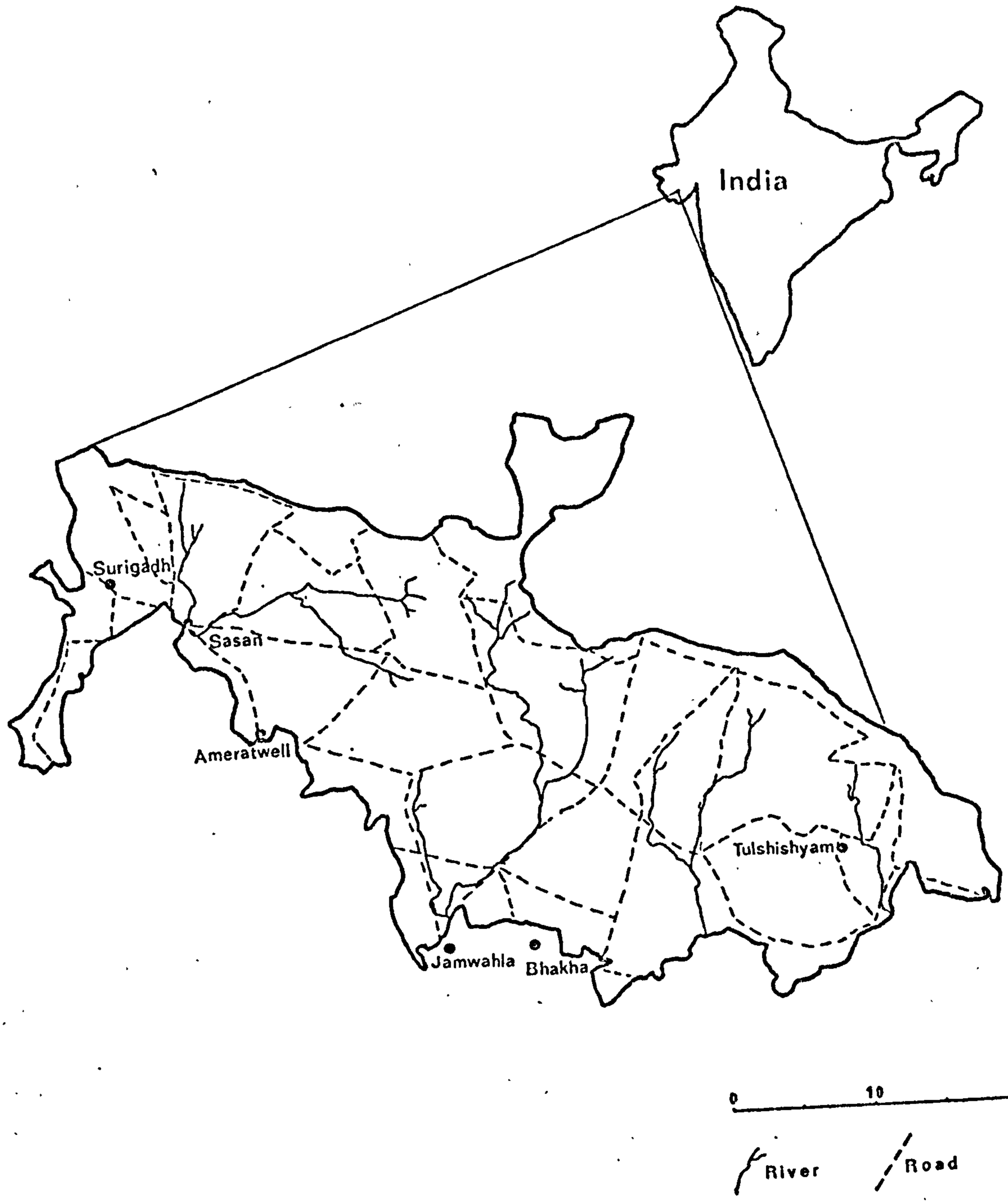



Fig. 2 : Gir Forest Wildlife Sanctuary

punctuated with evergreen riverine forests, forming a distinct network over the sanctuary, composed of a dense understorey of evergreen shrubs and an upperstorey of Syzygium rubicunda, Pongamia glabra and a variety of other species. During the monsoon the forest is luxuriantly green with impeded vision at ground level. In dry weather, the ground cover becomes greatly reduced, partly because of drought, but mainly as a result of overgrazing. Loss of ground cover is most apparent on flat and gently sloping areas between hills, where most of the grazing occurs.

The large mammals include lions, leopards (Panthera pardus), jungle cats (Felis chaus), hyaenas (Hyaena hyaena), jackals (Canis aureus), porcupines (Hystrix indica), chital (Axis axis), sambar (Cervus unicolor), nilgai (Boselaphus tragocamelus), chinkara (Gazella gazella), four-horned antelopes (Tetracerus quadricornis) and wild boars (Sus scrofa); the small mammals have not yet been listed.

Over 5,000 semi-nomadic people, called maldharis, live in temporary hamlets inside the sanctuary, grazing large herds of water buffalo and some cattle. They milk their stock to make ghee, a clarified butter, and the sale of this and dung forms the basis of their economy. Approxi-:mately 135 villages, each consisting of about six huts, are scattered over the sanctuary. Large numbers of cattle are also brought into the sanctuary daily from c 70 villages within 2 km of the boundary. In the monsoon, stock is brought from more distant villages, nearly doubling

the number of grazing domestic animals.

The 1265 $km^2$ sanctuary is administered by the Gujarat State Forest Department, which is primarily concerned with silviculture and forest management, the protection of wild-:life, and the maintenance of a small, but growing, tourist industry. Outside the sanctuary the land is administered by local village leaders, primarily interested in cultiva-:tion.

# CHAPTER 4

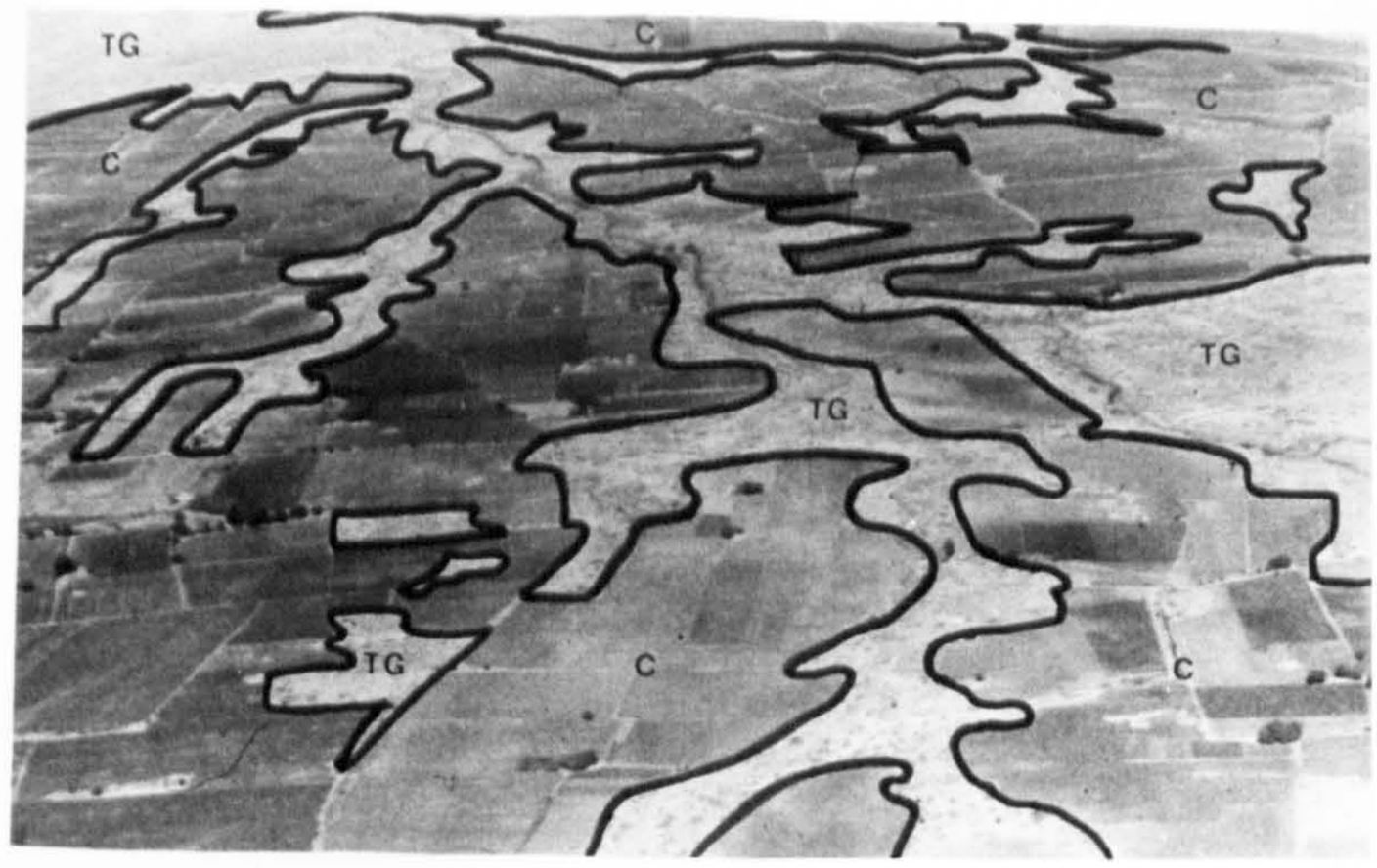
# PATTERN OF LAND USE

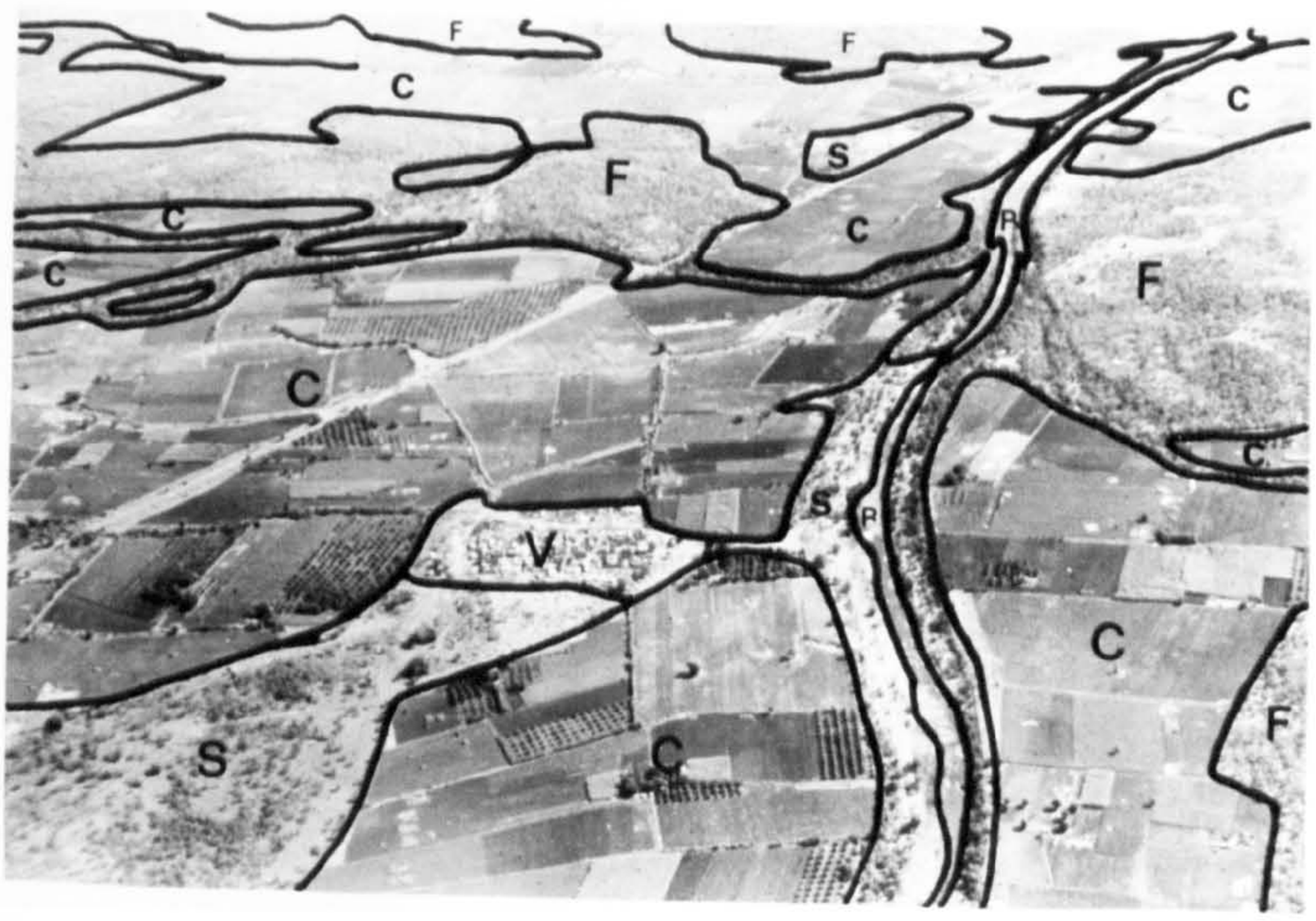
## INTRODUCTION

The pattern of land use outside the sanctuary and the encroachment of cultivation upon the sanctuary had an important bearing on the amount of available lion habitat, and was therefore assessed. In 1871-72 the area under forest outside the sanctuary was c 1850 $km^2$ and in 1969 c 240 $km^2$. Estimates from lion tracks in 1955 (Wynter-Blyth, 1956) and 1968 (Dalvi, 1969) showed a decrease from 130 lions to 50 outside the sanctuary. By replacing both the forest and grazing land with ploughed fields surrounded by stone walls, over the years cultivators gradually replaced the original habitat which supported wild and domestic herbivores on which lions depended. Even oxen, used in ploughing, were sent elsewhere in the growing season. Cultivators near the sanctuary hired armed guards in the crop growing season to protect their fields against wild animals at night. Wild boar, which were found to have a high occurrence in lion faeces in relation to abundance, were the most frequently destroyed. Culti-:vators also conflicted with wildlife by monopolising many sources of water.

## METHODS

In 1968-70 oblique aerial photographs were taken of the southern boundary of the sanctuary and the area outside. The patterns of land use were classified into their easily identifiable forms, such as cultivation, forest, treeless grazing land, village sites, etc., (fig.3). The propor-:tions of each land class were determined with a standard planimeter.




C = Cultivation
F = Forest
S = Scrub
V = Village
R = River
TG = Treeless grazing land

Fig.3: Classification of land use

Assuming that any one type of land use was not photographed preferentially it follows that the average proportions of each represented in the oblique photographs equalled the proportions of each type which existed on the ground.

A comparison was made between my data and land use figures obtained from the Gujarat Bureau of Economics and Statistics for 1963 for five of the eight talukas (counties) surrounding the sanctuary, and a map prepared depicting encroachment of cultivation on the sanctuary. In it, I combined my findings of 11 photographed areas of encroach-:ment, with information obtained from the Gujarat forest department on cultivation within the sanctuary and on land sanctioned to forest settlement villages.

## RESULTS

Land use outside the sanctuary: Of the estimated 300 $km^2$ photographed, 69.1 ($\pm$ 7.5)% was cultivated, while 17.0 ($\pm$ 4.7)% was treeless grazing land, 10.0 ($\pm$ 10.3)% was forested (largely acacia), 1.1 ($\pm$ 0.7)% was occupied by villages, and 2.8 ($\pm$ 3.1)% was scrub with the occasional river (Table 1). Much of the treeless grazing land or wasteland was flat, and barren in the dry season and affording little cover for lions to catch prey unobserved by herdsmen (fig.4). The few forested tracts were largely fragmented. Measures of land use for five talukas surrounding the Gir sanctuary obtained from the Gujarat bureau of economics and statistics showed that in 1963,

Table 1: Proportional occurrence of land use classes assessed from oblique aerial photographs outside the southern boundary of the Gir sanctuary.

| Aerial photo | Cultivation | Treeless grazing land | Scrub and river habitat | Forest | Village |
|---|---|---|---|---|---|
| 1 | 83.2 | 16.8 | 0 | 0 | 0 |
| 2 | 76.8 | 22.8 | 0 | 0 | 0.4 |
| 3 | 72.5 | 27.5 | 0 | 0 | 0 |
| 4 | 61.3 | 9.0 | 27.3 | 0 | 2.4 |
| 5 | 79.3 | 16.2 | 2.4 | 0 | 2.1 |
| 6 | 73.8 | 23.4 | 2.8 | 0 | 0 |
| 7 | 12.5 | 0 | 0 | 86.2 | 1.3 |
| 8 | 78.0 | 22.0 | 0 | 0 | 0 |
| 9 | 79.4 | 20.0 | 0 | 0 | 0.6 |
| 10 | 66.0 | 34.0 | 0 | 0 | 0 |
| 11 | 74.1 | 19.5 | 5.3 | 0 | 1.1 |
| 12 | 87.8 | 11.8 | 0 | 0 | 0.4 |
| 13 | 47.1 | 3.2 | 0.6 | 48.7 | 0.4 |
| 14 | 74.0 | 26.0 | 0 | 0 | 0 |
| 15 | 74.1 | 24.4 | 0 | 0 | 1.5 |
| 16 | 64.0 | 30.0 | 0 | 0 | 6.0 |
| 17 | 83.2 | 16.4 | 0 | 0 | 0.4 |
| 18 | 62.7 | 0 | 14.0 | 20.1 | 3.2 |
| 19 | 63.3 | 0 | 0 | 35.3 | 1.4 |
| Mean | 69.1 | 17.0 | 2.8 | 10.0 | 1.1 |
| Standard deviation | 16.7 | 10.5 | 6.8 | 23.0 | 1.5 |

66% of the land was cultivated (Anon, 1967a), or similar to the results which I had obtained. In 1969 the amount of forest outside the sanctuary was approximately 240 $km^2$, or about 5% of the eight talukas adjoining the sanctuary (Gujarat forest department, pers. com.) I recorded about 10% forest outside the sanctuary, which was not unexpected because most of my photographs were along the sanctuary boundary where the majority of the remaining forest existed.

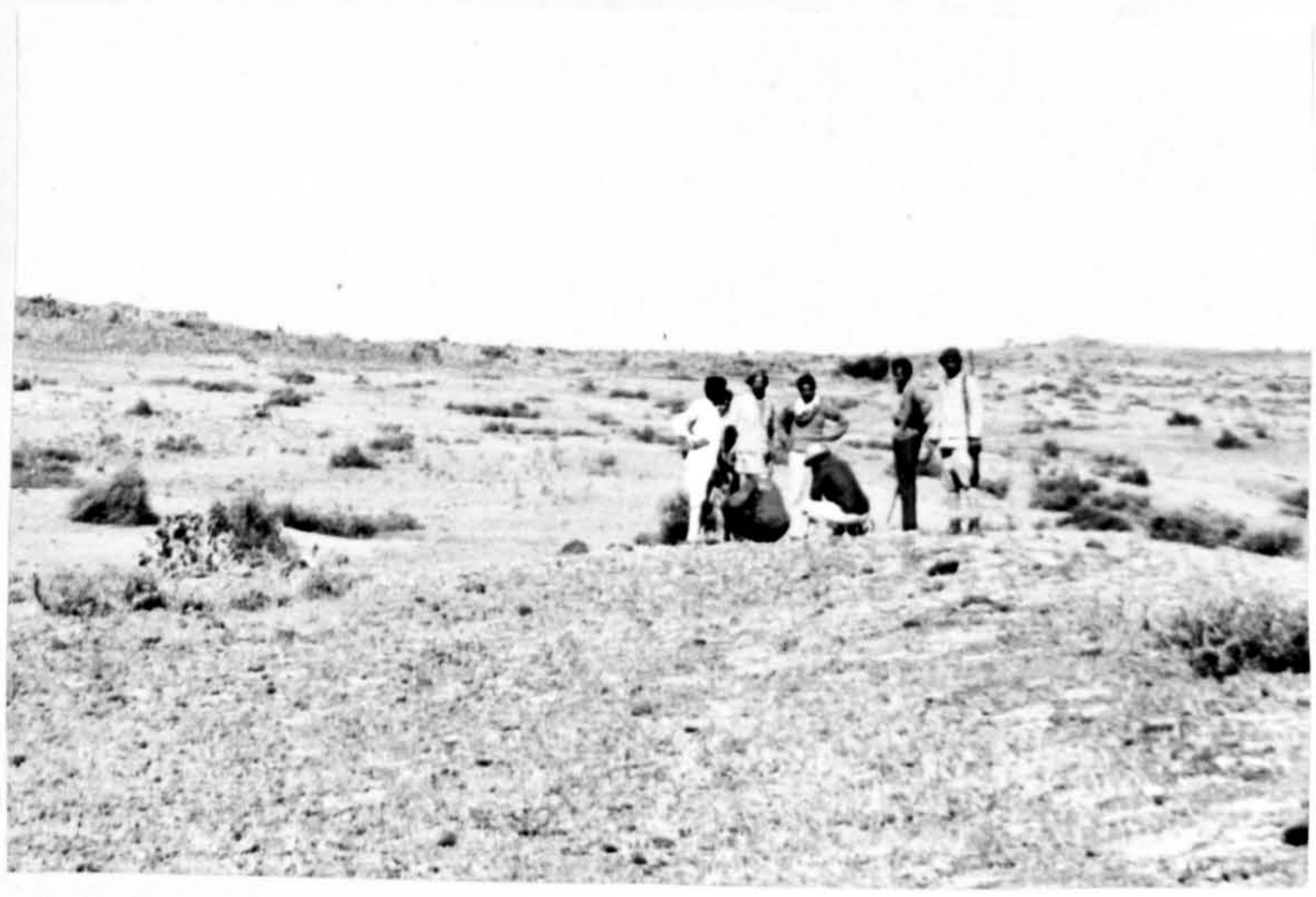
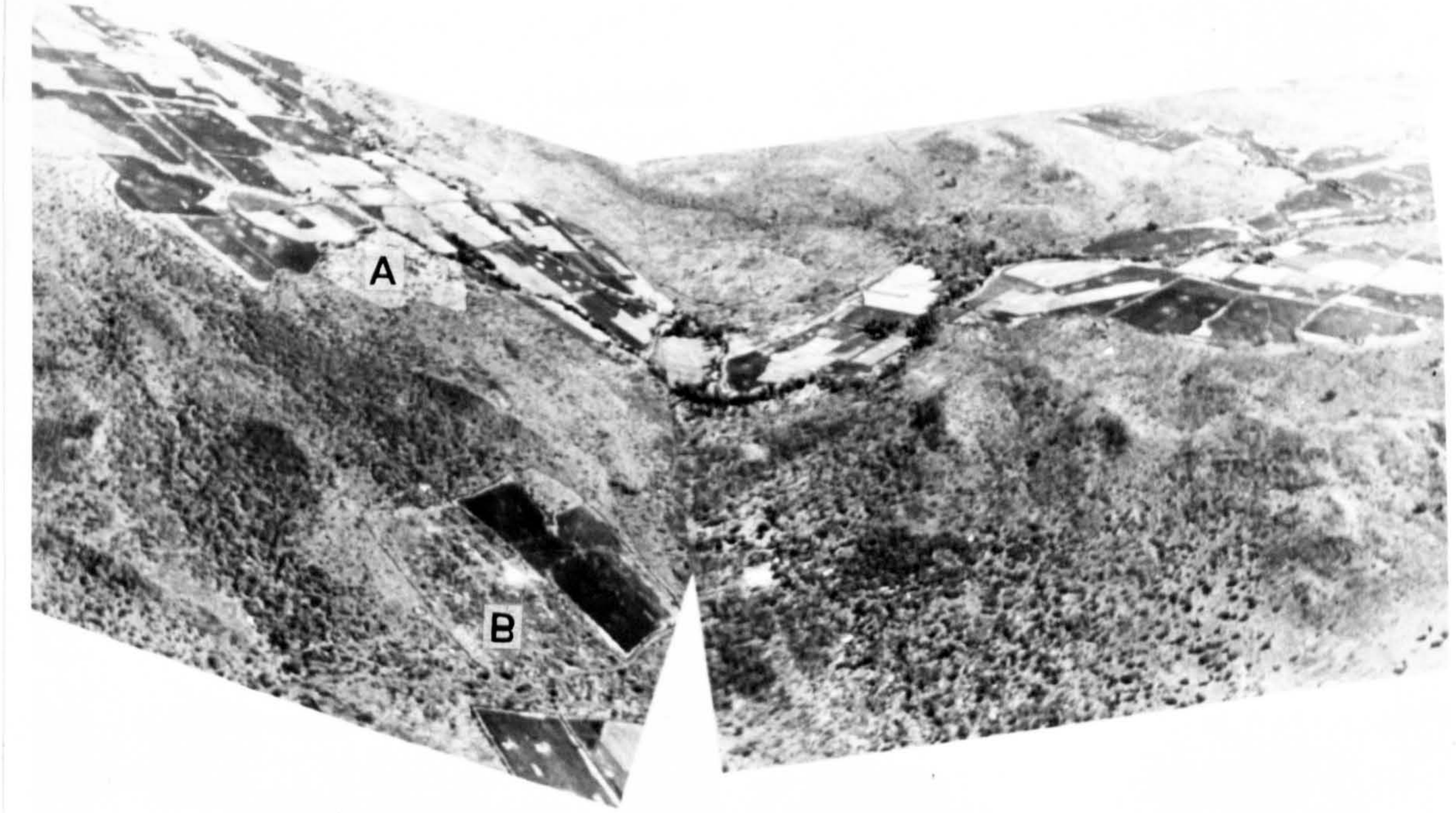


Fig.4: Treeless grazing land

Encroachment upon the sanctuary: aerial photo-:graphs showed that approximately 20 $km^2$ of the sanctuary was cultivated along the southern boundary, associated mostly with forest settlement villages. Rapidly expanding cultivation around Surigadh was dividing the sanctuary into two parts (fig.5). At the time of writing, the south western part has been classified as no longer part of the sanctuary (Tolia, pers. com.). In the 1955 lion census, Wynter-Blyth (1956) reported that this area contained one



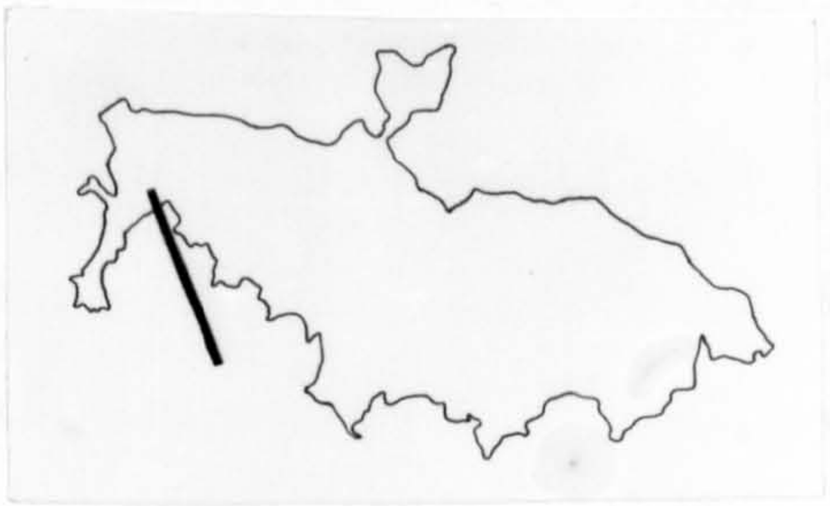



Fig.5: Cultivation penetrating the sanctuary near Surigadh. Two partially cleared fenced areas (A and B) indicate further expansion in progress.

of the highest lion densities in the sanctuary. The trend towards a reduction in the size of land under protection is not new. When the Gir forest reserve was renamed the Gir forest wildlife sanctuary in 1965 about 3% was not included in the west around Malenka. Much of this area has since been cultivated.

Aerial photos showed that cultivation north of Jamwahla, Ameratwell and Bhakha was also fragmenting parts of the sanctuary (fig.6). Cultivation was also observed near Tulshishyam, in the middle of the sanctuary (fig.7). More land was being cleared in 1971. I combined the findings from my aerial photos with estimates made by forest department surveyors in 1968 and 1970. Allowing for areas of overlap, approximately 6% of the sanctuary was either cultivated or allocated for development (fig.8).

## DISCUSSION AND CONCLUSION

I assessed the pattern of land use from oblique aerial photos for only a portion of the sanctuary and surrounding landscape. Vertical aerial photos of the entire sanctuary were reputedly made by the Indian defence department in 1963 and again in 1970. However, neither I nor the Gujarat forest department had access to these. This was unfortunate, because the existence of two surveys would have made it possible to make both a very accurate assessment of the land use pattern, and to determine the rate of encroachment in the time between the two surveys.

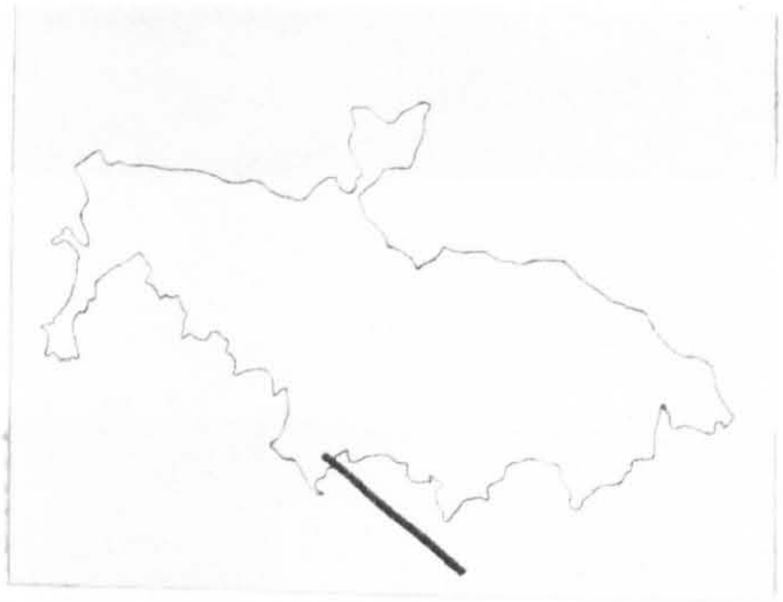


Fig.6: Cultivation penetrating the sanctuary north of Jamwahla

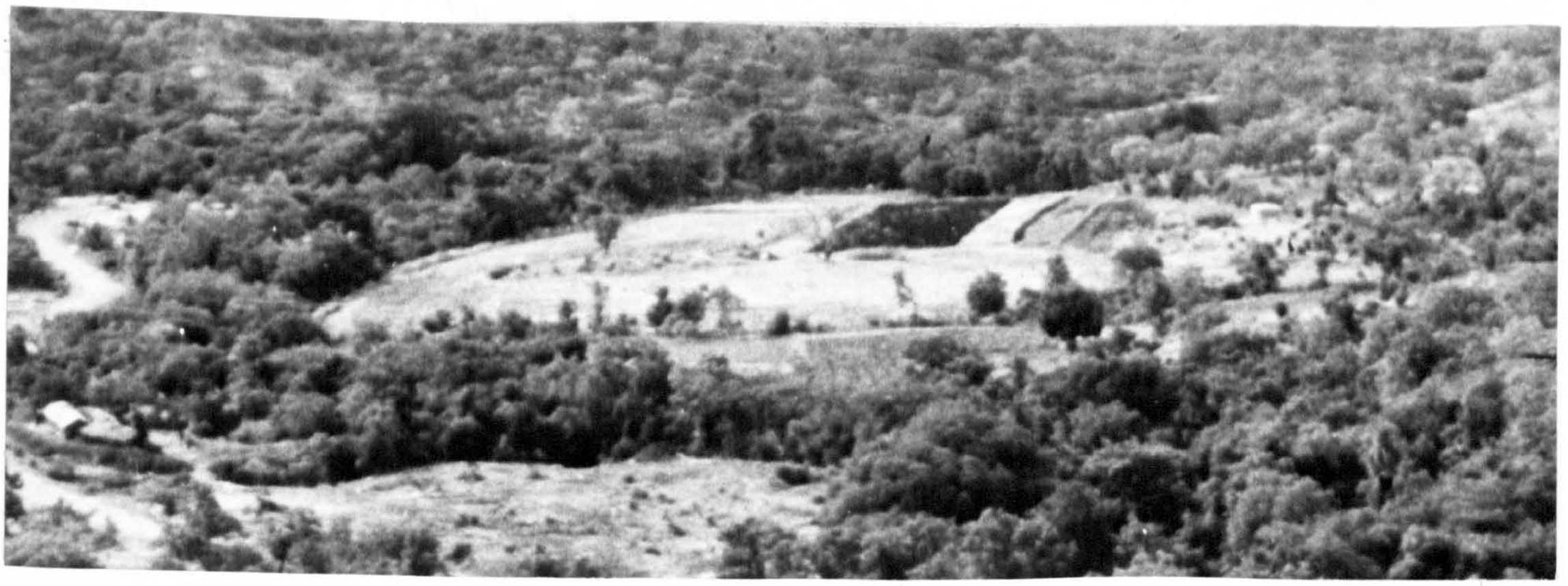


Fig.7: Cultivation within the sanctuary south of Tulshishyam

Cultivation (Joslin 1968-71 aerial survey)

Cultivation (Suthar, Gujarat Forest Dept., 1970)

Land sanctioned to forest settlement villages (Samtani, Gujarat Forest Dept., 1968)

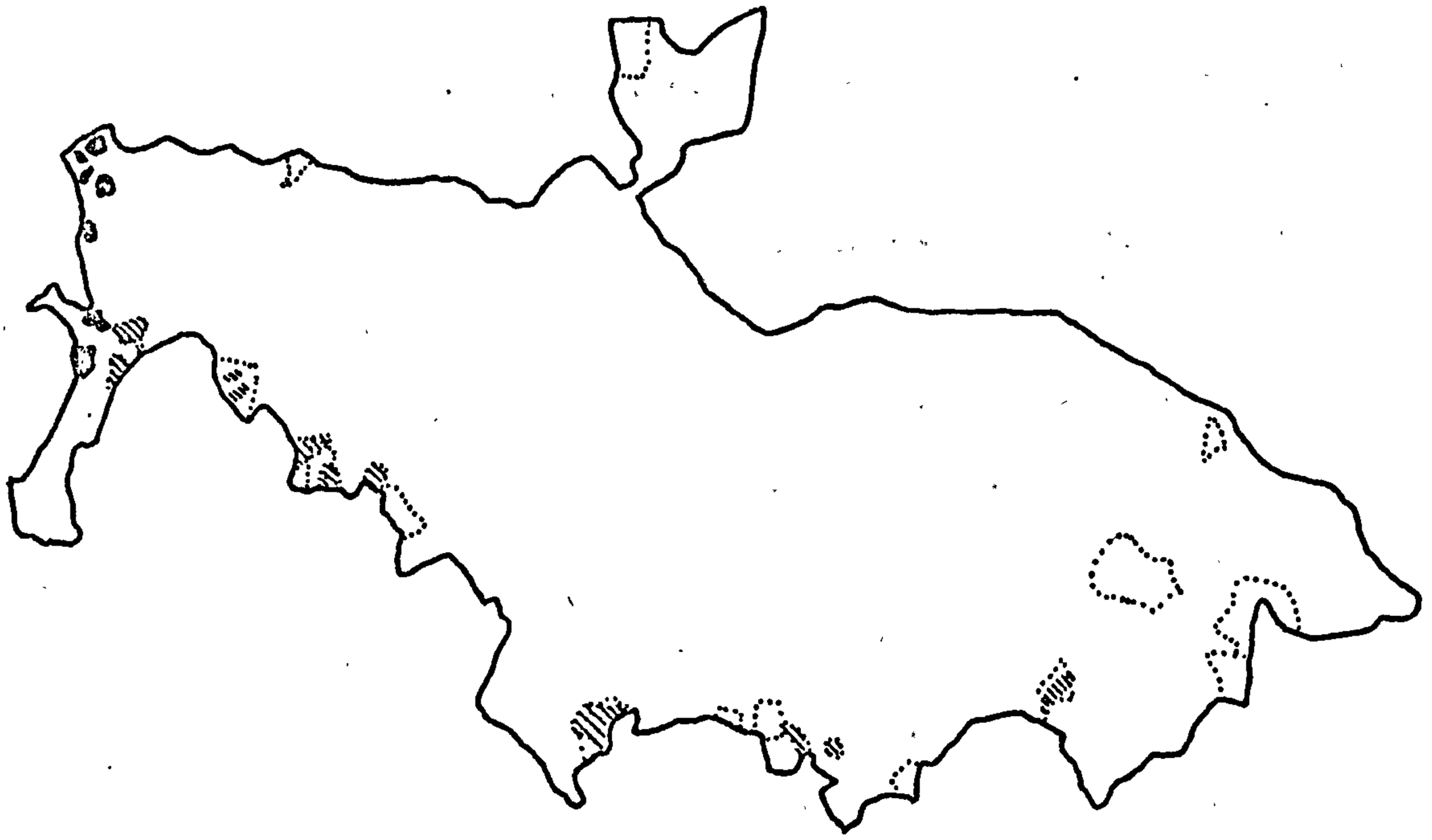


Fig. 8: Distribution of known encroachment within the Gir sanctuary

My results showed that only 13% of the land outside the sanctuary supported both the prey and cover required to support lions -- 10% forest, 3% scrub and riverside cover -- while within the sanctuary an estimated 94% was forested or not allocated for development (fig.9). Although cultiva-:tion inside the sanctuary was not very significant, if its rate of forest displacement was as rapid as it appeared to be, and as it had been outside during the previous 100 years, the consequences would be serious for lions. There was no evidence that lions were able to adapt to a predomin-:antly cultivated landscape, and the decline in lion numbers outside the sanctuary was associated with the loss of forest. In contrast, leopards have survived in low numbers in the vicinity of agricultural communities. They have adapted themselves to resting in sugar cane fields during the day , and, by preying at night on small animals such as dogs considered worthless by farmers, have not been as heavily persecuted. Leopards are also less vulnerable because of their shy, solitary and strongly nocturnal habits.

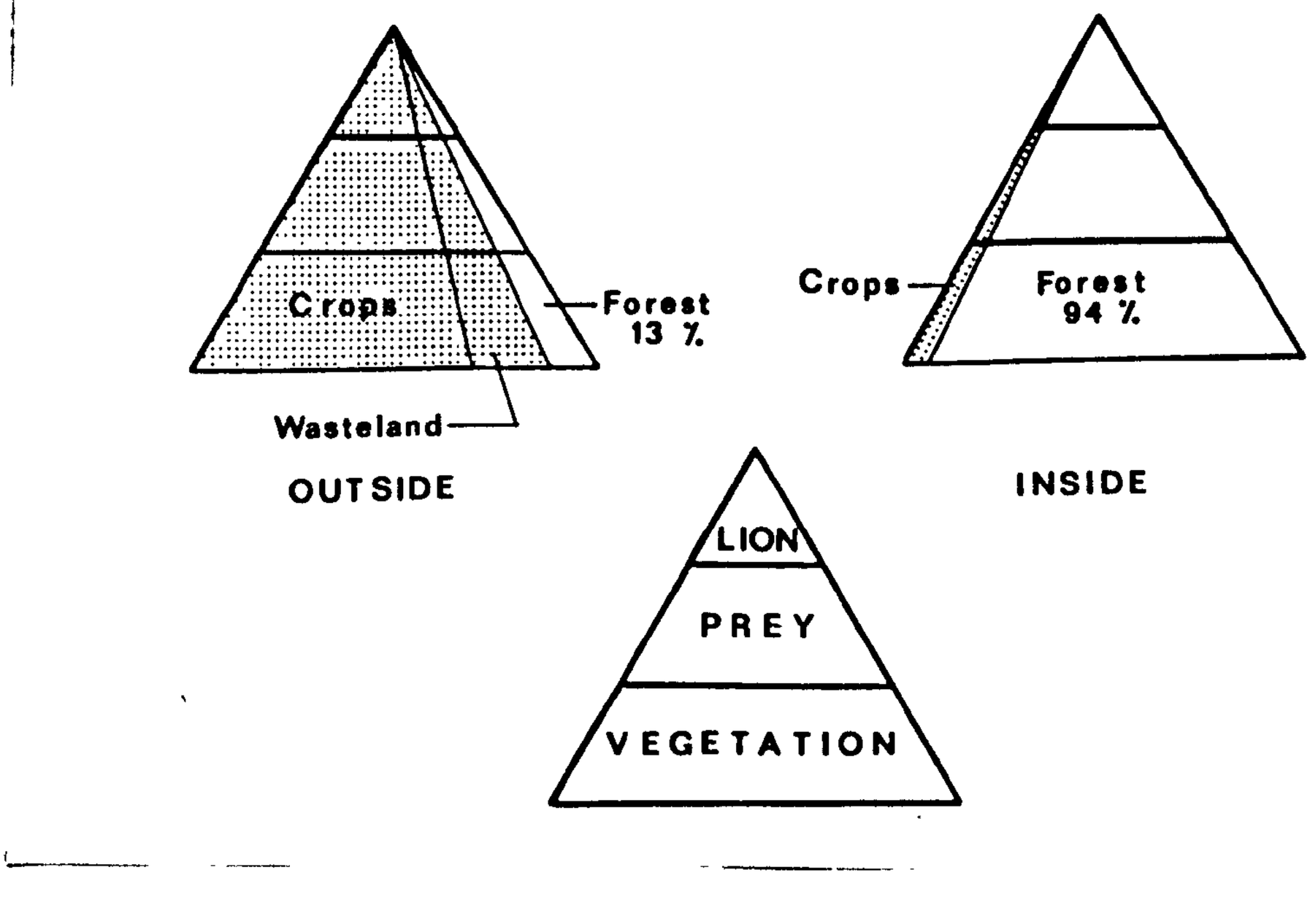



Fig.9: Pattern of land use inside and outside the sanctuary.

# CHAPTER 5

# SIZE AND COMPOSITION OF PREY POPULATION

## INTRODUCTION

The aim was to estimate the sizes of the different populations of wildlife and domestic prey which the lions utilised, inside the sanctuary. Wildlife was more or less restricted to the sanctuary, while domestic stock moved in and out. There was a resident domestic population of many thousands, consisting of buffalo and small numbers of cows, oxen and camels, and these were cared by herdsmen living in 135 small villages. Stock from 19 forest settlement villages forming enclaves on the boundary, were also allowed to graze permanently within the sanctuary. In the monsoon the number of domestic stock grazing in the sanctuary approximately doubled, some travelling more than 20 km from the cities of Junagadh, Una and Veraval. Moreover in years of drought (about one in three) stock from stricken villages were often sent to the sanctuary in the dry season. In the drought years of 1969-70 several thousand cows and oxen were brought from Kutch 300 km to the north of the sanctuary.

## WILDLIFE NUMBERS

Methods: Numbers of wildlife were assessed by road counts, counts at waterholes, and from casual counts. A separate count was made of langur numbers in riverine habitat.

a) Road counts: These were done at night, along the dense network of roads covering every habitat within the

sanctuary. They were done at night, in March, April and part of May 1969 over 1025 km of road, travelling all routes at least twice. The operation involved 2-3 men, one to drive, one to stand on the back seat of an open jeep, scanning both sides of the road with a 12 volt sealed beam spotlight, and usually a third man to assist in the sight-:ing. The speed of 10-20 km per hour was varied by the scanner according to visibility. The scanner spotted animals mainly by eye reflections, but also by body shape. Once spotted, an animal was identified by binoculars. Ungulates did not bolt at the sight of the passing vehicle, however they did look. This aided the scanner in spotting. Road counts were usually made from 2100-0100 hrs when all species of interest except langurs were assumed to be active. The average width of the strip scanned for wild-:life was $\leq$ 75 m, or equal to the average approximate dis-:tance at which wildlife was sighted.

b) Counts at waterholes: These were done in March-April 1969 towards the end of the dry season when water was limited to a few sites which wildlife were more likely to visit. Three hundred hours of observations were made by 14 people from hides constructed at five waterholes in the western half of the sanctuary. Sixty-one percent of the observations were made on moonlit nights, and the rest in daytime. Counts at waterholes gave a measure of relative proportions of the different wildlife.

c) Casual counts: Wildlife were counted 'casually' between 1968-71 over at least 2500 km of roads mostly in

the day time, traversing the sanctuary a great many times, in the course of other investigations. This gave an estimate of the relative numbers of the different species.

d) Counts of langurs: Langurs were associated with riverine habitat. From ordinance survey maps, I measured approximately 800 km of riverine habitat in the sanctuary, using an opisometer, a device for measuring distances along an irregular line. An idea of the fre-:quency of occurrence of langur troups per km of riverine forest was obtained by walking 10 km of riverine habitat. Average troop size was assessed by sample observations in 1968, and the total estimated by extrapolating.

Results: The 1969 road count was made along 1025 km of road, over an area of approximately 77 $km^2$. Three hundred and thirty-eight wild ungulates were sighted, of which 73.7% were chital, 11.5% sambar, 6.8% nilgai, 5.3% wild boar, 1.5% four-horned antelope and 1.2% Indian gazelle. The estimated population of each species in the sanctuary extrapolated from the sample count is shown in Table 2. There were an estimated 5000-6000 wild ungulates in the sanctuary.

The data obtained from road counts, counts at water-:holes and casual counts were correlated. The percentage occurrence of each species of wild ungulate in each count is shown in Fig.10. These results show little variation between the three methods for most species. Averaging the results 70.3% of sightings were of chital, 10.0% nilgai,

Table 2: Estimate of wild ungulate numbers in the Gir sanctuary

| Species | Number of sightings in 1969 road count (1025 km x 75 m = 76.9 $km^2$) | Estimated sanctuary population (1265 $km^2$) |
|---|---|---|
| Chital | 249 | 4100 |
| Nilgai | 23 | 400 |
| Sambar | 39 | 600 |
| Wild boar | 18 | 300 |
| Four-horned antelope | 5 | 100 |
| Indian gazelle | 4 | 50 |
| Total | 338 | 5550 |

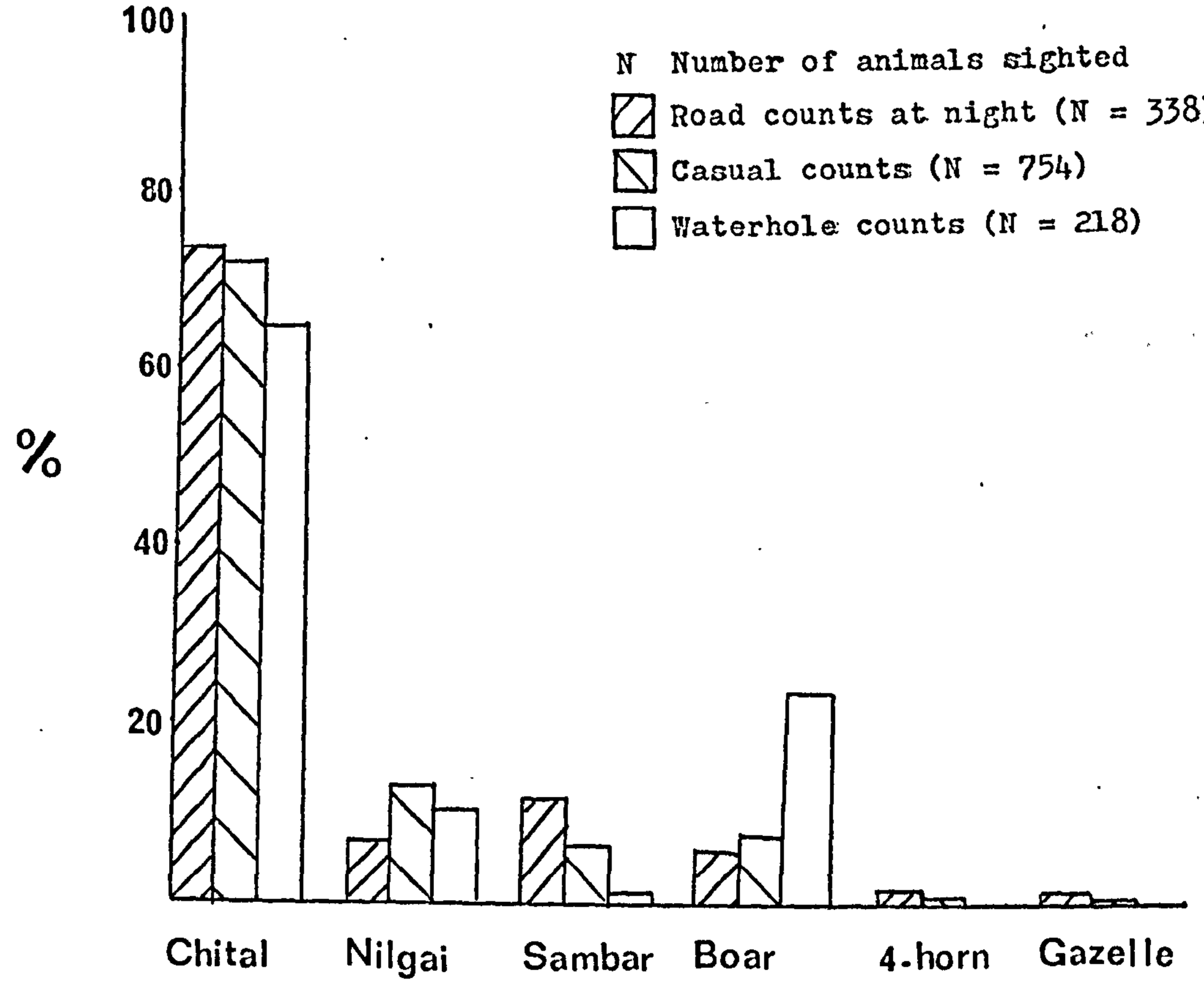



Fig. 10: Percent occurrence of six species of wild ungulates in each of three counts

8.6% wild boar, 6.4% sambar, 0.9% four-horned antelope and 0.5% Indian gazelle. On the 1969 road count two other potential prey species were also enumerated--12 porcupine and 174 Indian hares, or an estimated sanctuary population of c 200 porcupines and 3000 Indian hares.

In the casual counts, the average troop size of langurs in 15 observations was 7, but I rarely saw all animals present. Walks along riverine habitat indicated about one troop in every kilometer, or c 770 langur troops in the sanctuary, assuming they were only associated with riverine habitat. The total population of langurs in the sanctuary was approximately 5500. This is a rough estimate, but gives an idea of the marked abundance in relation to wild ungulates.

Discussion and conclusion: The 1969 road count covered c 77 $km^2$, and showed 338 wild ungulates, i.e. 4.4 ungulates per $km^2$, or 5000-6000 ungulates in the sanctuary, of which 73.7% were chital. The road counts were biased in favour of gregarious animals because the eyes of only one animal needed to be seen for more to be discovered. The area examined might not have included habitat types typical of the whole sanctuary, as roads tended to traverse more valleys than hills. Roads in the western half of the sanctuary were surveyed more than twice as frequently as those in the east. However, when the results were compared with casual counts, and with counts at waterholes the proportions of each species were in reasonable agreement,

indicating that the errors involved in the 1969 night road count were probably not significant. In 1970, Berwick et al, (1971) made road counts of wild ungulates both divided between day and night counts covering equally both the east and west of the sanctuary and censusing c 111 $km^2$. From these counts he estimated the sanctuary population to be c 6200 ungulates, or within 13% of my estimate.

I saw a higher proportion of wild boar at waterholes than in road counts. It was my impression before the survey that wild boar favoured riverine habitats. The size of the Indian hare population was probably under-estimated, because they were difficult to spot in road counts, except along road sides. The size of the langur population may have been underestimated because the average troop size used in the calculation was based on an average obtained from troops seen, where it was unlikely that I saw all animals in all cases. In spite of this, the population estimated was larger than the estimated size of the chital population.

## DOMESTIC STOCK RESIDENT IN THE SANCTUARY

Methods: In January-February 1971, the domestic stock in 20 villages within an area of 178 $km^2$, were counted during evening milking when all were corralled. An estimate of the population of domestic stock resident in the sanctuary was made by extrapolation:

a) from the count in 20 villages to that within the 135 sanctuary villages.

b) from the count in 178 $km^2$ to that within the 1265 $km^2$ sanctuary.

I then compared my estimates with the government count. The Gujarat forest department censused domestic stock annually in order to obtain grazing fees. The comparison was made in order to test whether the government count was dependable.

Results: Assuming a constant relationship between stock numbers and a) village numbers or b) size of area, 20,000 and 19,000 animals respectively were estimated to occur in the sanctuary (Table 3), 15.1 - 15.9 animals per $km^2$. The difference between the two population estimates was less than 6%. The sample population con-:tained 92.0% buffalo, 5.1% cows, 1.9% camels, 0.8% oxen and 0.1% horses and averaged 142 head per village. Only three villages in the sanctuary, but outside the sample area were known to possess goats, totalling less than 100. A few villages not included in the sample occasionally and illegally kept large numbers of sheep.

Table 3: Numbers of livestock counted in sample area in 1971, and the estimated population in the Gir sanctuary

| | Buffalo | Cow | Ox | Camel | Horse | Total |
|---|---|---|---|---|---|---|
| Actual count for 20 villages in an area of 177 $km^2$ | 2607 | 145 | 24 | 55 | 3 | 2834 |
| Percent | 92.0 | 5.1 | 0.8 | 1.9 | 0.1 | |
| Estimate for the 135 villages in the Gir sanctuary | 18530 | 1030 | 170 | 390 | 20 | 20140 |
| Estimate for the 1265 $km^2$ Gir sanctuary | 17600 | 980 | 160 | 370 | 20 | 19130 |
| Average for the two estimates | 18065 | 1005 | 165 | 380 | 20 | 19635 |

Table 4: Density of livestock (head/$km^2$) assessed from a sample count made in 1971 compared with that obtained by the Gujarat government when counting the entire Gir sanctuary in 1969

| | Buffalo | Cattle | Horses and camels |
|---|---|---|---|
| 1971 sample count | 14.6 | 0.9 | 0.3 |
| 1969 government count | 12.2 | 3.7 | 0.3 |

I compiled the figures for the total sanctuary for 1969 from the government records for each village which were kept in six range forest offices within the sanctuary. The government count for the total population was approxi-:mately 20,500, or within 5% of the mean of my two estimates. The 'official' densities of buffalo, horses and camels were similar to mine, but those of cattle (cow and oxen) were markedly different (Table 4). By calcu-:lating cattle densities for each of the six ranges from the official records, it became apparent that the range in which I had taken my sample contained the lowest cattle density, and was unrepresentative of the sanctuary as a whole. In the official count the percent occurrence of cattle was 22.9%; for buffalo it was 75.4% and for both camels and horses 1.7%.

## DOMESTIC STOCK BELONGING TO FOREST SETTLEMENT VILLAGES

Methods: Nineteen forest settlement villages were sited along the sanctuary boundary. They were originally established to provide labour for working the forest, and were given land concessions for cultivating during the off season. Forest settlement villages were permitted to graze their livestock inside the sanctuary. My assistants and I counted the bovids in three of these villages (Ameratwell, Sasan and Surigadh) in February, 1971. During the milking period most stock were kept in groups of 1-3, rather than corralled in larger groups, as had been the case for sanctuary villages. The most convenient way of enumerating this stock was not by counting them in such fragmented groups, but instead talling their numbers at the few points of access into villages when the stock returned after grazing. This count excluded bovids of less than one year of age which did not graze beyond the confines of the village, and which were almost entirely unavailable to lions.

In 1969 the Gujarat forest department also counted stock in some of the forest settlement villages. I compared their counts with my own for the same three villages after excluding bovids less than one year of age from the total.

Results: Assuming the relationship between the 3 villages and the number of stock was the same as for the 19 villages, then the total number of stock in the forest

settlement villages was 5550, including 64.8% buffalo, 23.5% cow, 10.1% oxen, and 1.6% horse, donkey and camel. The government count for the three villages was within 11% of my own count, and contained almost the same percent occurrences as that which I had obtained (61.2% buffalo, 23.4% cow, 15.1% oxen, and 0.6% horse, donkey and camel).

## TRANSIENT DOMESTIC STOCK

**Methods:** Daily cattle and buffalo more than one year old from 52 villages outside the sanctuary, but within approximately 2 km of its boundary were allowed to graze within. Oxen older than about three years of age were used for labour and were not sent for grazing, except in the monsoon. I counted cattle and buffalo in a sample of three villages in February 1971. The method of count-:ing was the same as for enumerating stock in forest settlement villages. Bovids less than one year and oxen greater than three years of age were not counted. The grazing population was estimated for the 52 villages within 2 km of the sanctuary boundary.

In 1961 the Gujarat bureau of economics and statistics compiled livestock figures for the state. Although counts for each village were not available, I was able to obtain total figures for bovids and the number of villages sur-:veyed for 5 of the 8 talukas (counties) adjoining the sanctuary (Anon, 1967b). After excluding oxen more than three years old and all bovids less than one year, the count was extrapolated for 52 of the 529 villages and compared with my own estimate for the same number of villages.

**Results:** Assuming the relationship between the three villages and the number of stock was the same as for the 52 villages, then the total number of stock daily entering the sanctuary in the dry season was c 18,700. The

population contained 42% buffalo, 51% cow and 7% oxen. The government count extrapolated for 52 villages was within 1% of my own estimate. The population contained almost the same percent occurrences as that which I had obtained (56% buffalo, 36.0% cow and 8% oxen).

CONCLUSION

In the dry season c 49,900 ungulates used the sanctuary daily. These stock consisted of c 5600 (11%) wild ungulates, 20,000 (40%) resident domestic stock, 5600 (11%) domestic bovids belonging to forest settlement villages, and 18,700 (37%) transient domestic bovids. The prey consisted of 53% buffalo, 30% cow, 5% oxen, 8% chital, and 3% other wild and domestic species. At night the transient stock was largely unavailable to lions, because the stock left the sanctuary and was corralled behind high stone walls. Stock belonging to sanctuary villages and to a lesser extent forest settlement villages was more accessible than that belonging to outside villages, because they were corralled inside or on the edge of the sanctuary and the type of material used in fencing consisted almost entirely of thorn scrub. Fencing made of thorn scrub was a much less effective barrier against lions than stone fencing. At night only the wild ungulates remained available to about the same extent as they were in the day time.

# CHAPTER 6

# FOOD HABITS BASED ON FAECAL ANALYSIS

## INTRODUCTION

The percentage occurrence of each wildlife species in the lion's diet, and the proportion of wild and domestic prey, were assessed from the analysis of lion faeces. Scats were collected from the sanctuary, and to a limited extent on the outside, and were subsequently classified into those of lion origin and those of other predators on the basis of size. Of the remains of animals found in each scat, only hair was sufficiently unchanged from its original form to be useful in identifying species which had been eaten. However many scats contained few hairs, while the hairs from a number of species could be confused macroscopically. Moreover the literature gave no help in the identification of Indian mammals from hair. As a result, the study of food habits based on faecal analysis had to be preceded by the development of a key to hair identity using a combination of macroscopic and microscopic techniques.

## METHODS

Scat collecting and predator identification: Two men were hired to collect scats from the network of roads in the sanctuary. They walked or cycled together over each assigned route until all roads had been checked, collecting and tagging any scat with a diameter greater than c 20 mm and recording location and date in Gujarati. I then relabelled each in English, and classified them according to type. Two thirds of the scats were obtained in the

more accessible western half of the sanctuary, and the remainder when I made periodic shifts of my headquarters to the eastern half and employed six men to make collec-:tions. Scats were not gathered in the monsoon because they disintegrated so quickly that finding them was difficult.

Sixty-four lion scats and 31 scats of leopard, hyaena and dog were also collected. Except for those of hyaena, scats of each species were collected from sites where the animals were recently and regularly seen. Hyaena scats were identified as those which were white, extremely compact, and consisting of very fine powder with a few hairs. . . Hyaenas are able to digest bone completely (Kruuk, 1972) which accounted for the unusual properties of their scats. Approximately 90% of the lion scats had a diameter 45 mm or greater, while that of leopard, hyaena and dog was smaller. From this, scats of unknown origin, with diameter greater than 45 mm were assumed to be from lions.

Prey identification: Hairs from a few Indian mammals, such as porcupine and wild boar, could be identi-:fied from external appearances. For the others, cuticu-:lar scale impressions were first investigated, as a means of identification, following the method of Adorjan and Kolenosky (1969). However the crenate or flattened scale impressions, typical of most large Indian mammals, were not specific to the species or even genus (fig.11). Moreover,

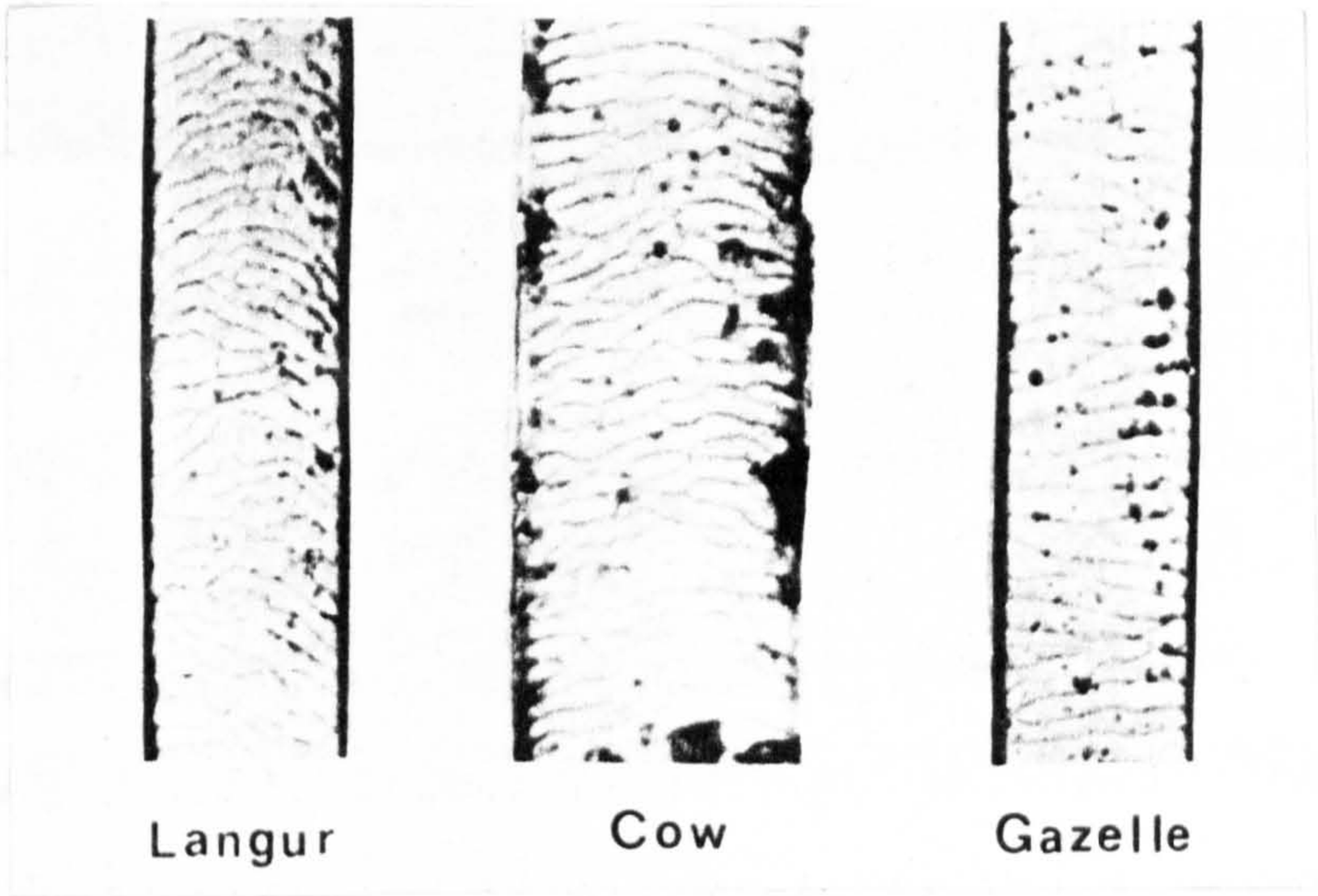



Fig.11: Cuticular scale impressions of three Gir mammals.

there were minor differences in scale patterns within each species, depending upon the age of the animal, the part of the body from which the hair was taken, and the part of the hair examined (proximal, medial or distal). I discarded this method as inadequate for my purpose.

Wildman (1954) and Akande (M.Sc. thesis) developed an alternative method for identifying wildlife species from the comparison of hair cross sections. The cross sectional outline of hair was sometimes circular, sometimes elongated; sometimes the medulla in cross section was simple and small, sometimes large and segmented; sometimes the medulla was irregular in shape, round, elongated, or flat-:tened along one side; and sometimes cortical pigment

granules were present. Together with the external appearance of hair, these differences were sufficient to separate wild species from domestic, and to identify all wild species and most of the domestic.

A reference collection of hair from known species was prepared by cleaning in ether, water and 70% ethyl alcohol in that order. Hair samples obtained from faeces were cleaned in a similar manner. Using the Wildman technique, cross sections were cut with a Hardy pocket microtome using colloidon of nitrocellulose as mountant (fig.12). The advantages of the Hardy microtome were the high quality of cross sections obtainable, and the convenience of the durable 25 mm x 45 mm microtome as a field tool.

Following the same technique, a number of hairs were removed from each identified 'lion' faeces, and cleaned in ether, water and 70% alcohol. Cross sections were prepared and the hair identified using my key constructed from the reference collection. The percent occurrence was ascertained for each species, and compared between various parts of the sanctuary and with the percent occurrence of available prey.

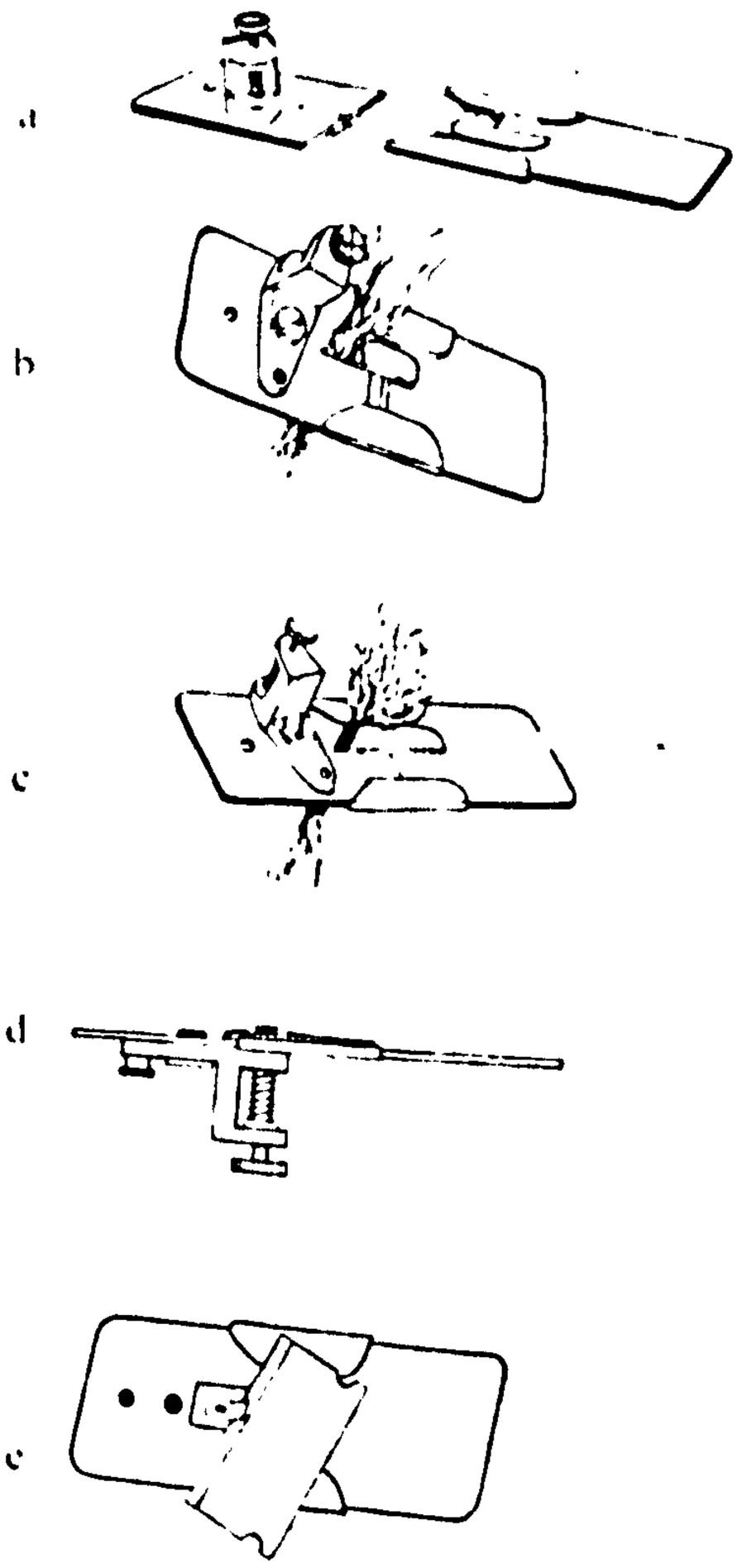


Fig.12: Stages in the manipulation of the Hardy microtome (adapted from Wildman, 1954).

a) Halves of the base plate separated.

b) Hair placed in slot, and tongue of base plate partially inserted.

c) Celloidin added to hair and tongue fully inserted.

d) Hair cut flush with base plate on either side. Screw operating plunger then turned until hair bundle is just visible above the base plate.

e) Thin section of hair cut and transfered to slide for microscopic examination.

## KEY TO HAIR IDENTIFICATION

The key makes use of one or two distinct traits in establishing the identity of each species. Verifications of hair identities were made by reference to the more detailed descriptions following the key.

In practice the identification of each unknown was clear cut, with the following exceptions:

a) There was sometimes an area of overlap in appearance and size between hair of chital and sambar.

b) Hair of four-horned antelope was sufficiently similar to that of some domestic species to require special attention.

c) Hair of a number of domestic species were similar in appearance. However further identification than "domestic" was not essential, as information about the killing of domestic stock could be obtained directly from an examination of herdsmen's losses.

| Characteristic | Species | Page |
|---|---|---|
| 1a Distal ends divided into two or more | Wild boar | 55 |
| b Not so.....go to 2 | | |
| 2a Proximal region completely rigid. Greater than 1 mm in width | Porcupine | 54 |
| b Not so.....go to 3 | | |
| 3a Clear distinction between guard hairs and fine hairs | Indian hare | 53 |
| b Not so.....go to 4 | | |

| Characteristic | Species | Page |
|---|---|---|
| 4a Not pigmented. Fine and straight. Greater than 30 mm in length | Langur | 54 |
| b Not so.....go to 5 | | |
| 5a Distal half black, proximal half not pigmented or light brown | Nilgai | 58 |
| b Not so.....go to 6 | | |
| 6a Pigmentation complete. Light brown. Greater than 40 mm in length. Subtle numerous waves throughout length | Sambar | 57 |
| b Not so.....go to 7 | | |
| 7a Pigmentation complete and very dark.....go to 8 | | |
| b Not so.....go to 9 | | |
| 8a Length greater than 100 mm | Buffalo | 62 |
| b Not so | Goat | 61 |
| 9a Medulla segmented....go to 10 | | |
| b Medulla simple.....go to 11 | | |
| 10a Medulla in cross section containing fewer than 20 blocks | Chital | 56 |
| b Medulla in cross section containing greater than 30 blocks | Sambar | 57 |
| 11a Cross sections bean shaped. If hair pigmented, then cortical pigment granules polarised in cross section | Indian gazelle | 59 |
| b Not so.....go to 12 | | |

| | Characteristic | Species | Page |
|---|---|---|---|
| 12a | Hair lacking pigment. Cortex outline slightly irregular. Medulla irregular | Sheep | 61 |
| b | Not so.....go to 13 | | |
| 13a | Medulla width 2-3 times cortex width.....go to 14 | | |
| b | Medulla width 1-2 times cortex width.....go to 15 | | |
| 14a | Cross section round to oval. Pigment granules in cortex, when present, are small and thinly distributed | Four-horned antelope | 57 |
| b | Not so.....go to 15 | | |
| 15a | Cross section distinctly round | Dog | 60 |
| b | Cross section round to oval .....go to 16 | | |
| 16a | Pigment granules in cortex, when present, are numerous and distinct.....go to 17 | | |
| b | Pigment granules in cortex, when present, usually small and thinly distributed | Horse | 63 |
| 17a | Length generally greater than 20 mm.....go to 18 | | |
| b | Length generally less than 20 mm.....go to 19 | | |
| 18a | Wavy. Waves greater than 10 mm. | Camel | 64 |
| b | Waves, if present, 1-2 mm. | Donkey | 63 |
| 19a | Length rarely exceeding 10 mm. Curved. Diameter approximately 50-120 μ | Camel | 64 |
| b | Length commonly exceeding 10 mm. Diameter approximately 30-50 μ | Cow and ox | 62 |

Indian hare

a) External appearance:
   1. Hair silky
   2. Abdominal hair white; hair from other regions brown
   3. Abundant fine under fur, each strand approxi-:mately 1 cm in length
   4. Under fur strands not straight, tending to bind together
   5. Guard hairs straight or slightly curved, approxi-:mately 1.5 cm in length
   6. Under magnification viewed through incident light, the medulla is clearly visible, laddered and uniserated in fine hair, while laddered and multiserated in guard hair

b) Cross section:
   1. Guard hairs 'bone' shaped, approximately 15 μ x 110 μ
   2. Fine hair round, tending to be square, approxi-:mately 10 μ in diameter
   3. Medulla densily pigmented, simple in fine hair, and divided into large segments in guard hair


X 3

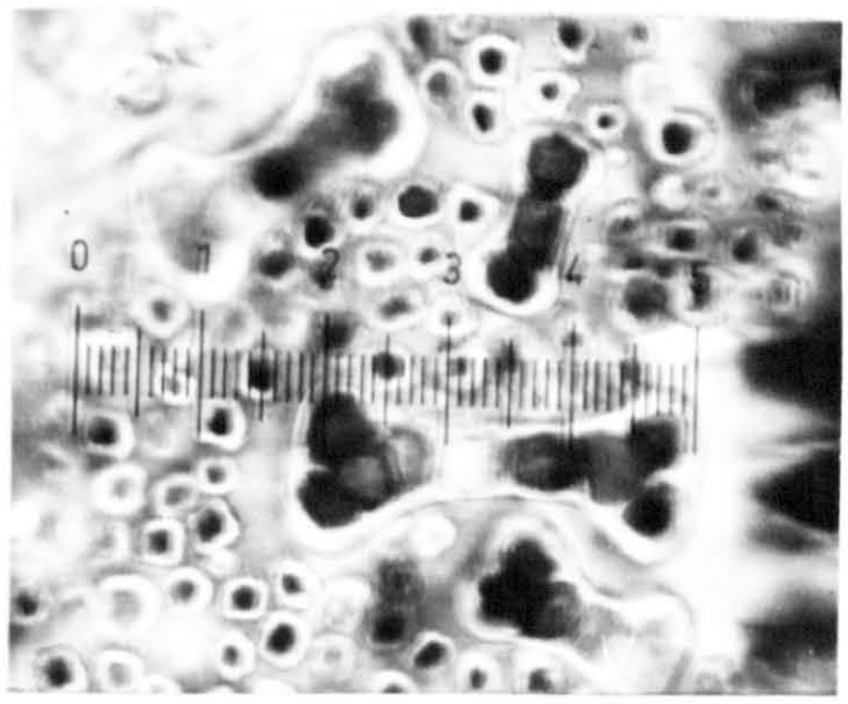



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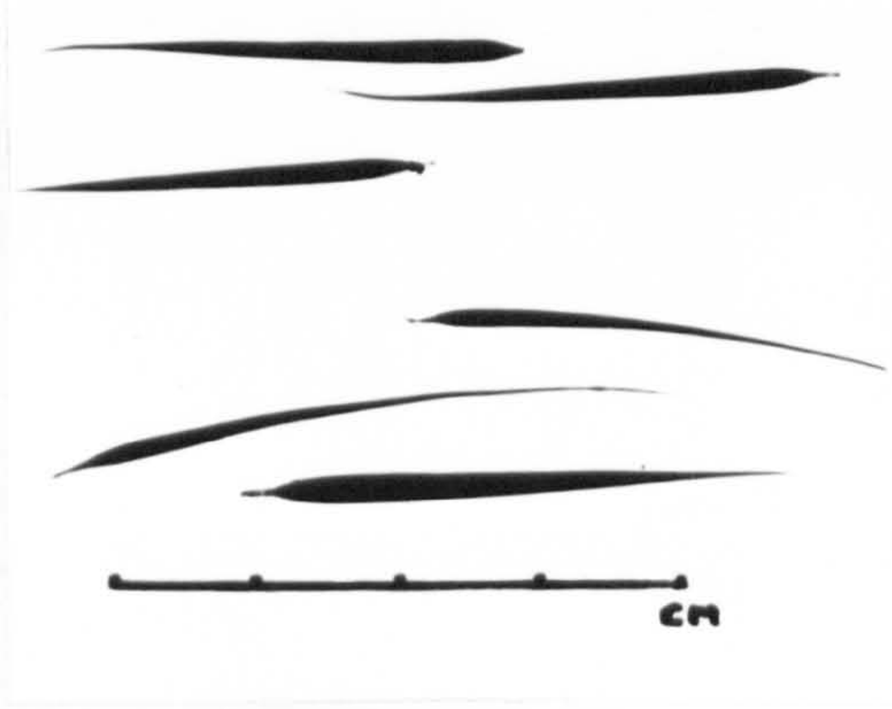
Fig.13: Whole mount and cross section of under fur and guard hair taken from Indian hare.

Porcupine

a) External appearance:
   1. Proximal region completely rigid
   2. Tapering throughout length; root conspicuous
   3. Shortest hairs rarely less than 3 cm in length

b) Distal cross section:
   1. Hair outline oval with parallel sides
   2. Cortex width approximately equal to one third of the medulla width
   3. Rarely less than 1 mm in length

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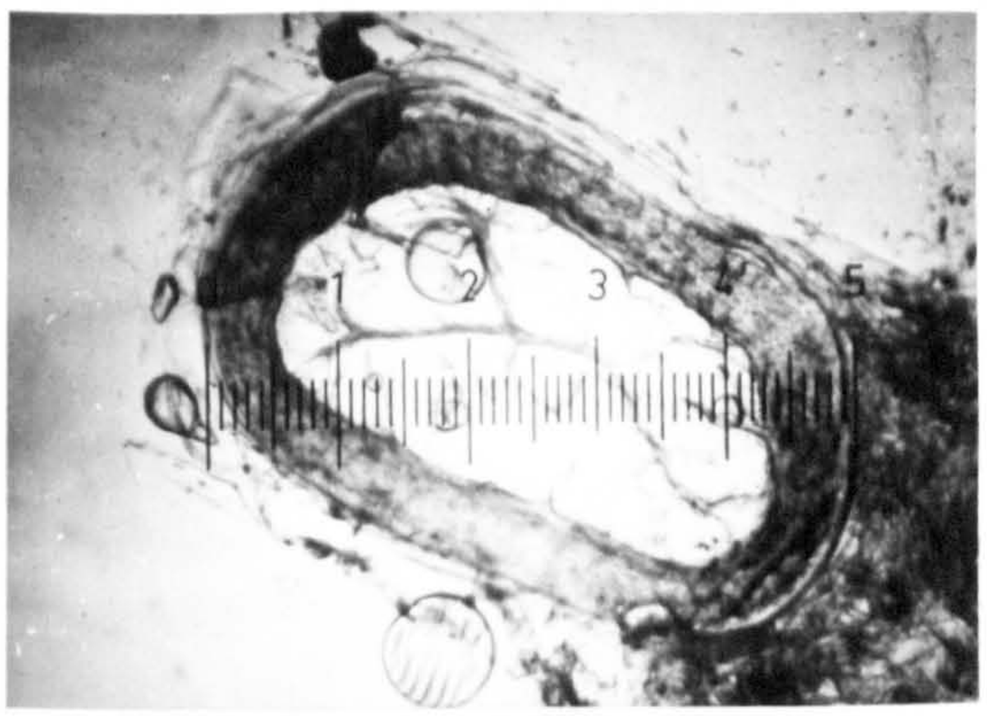


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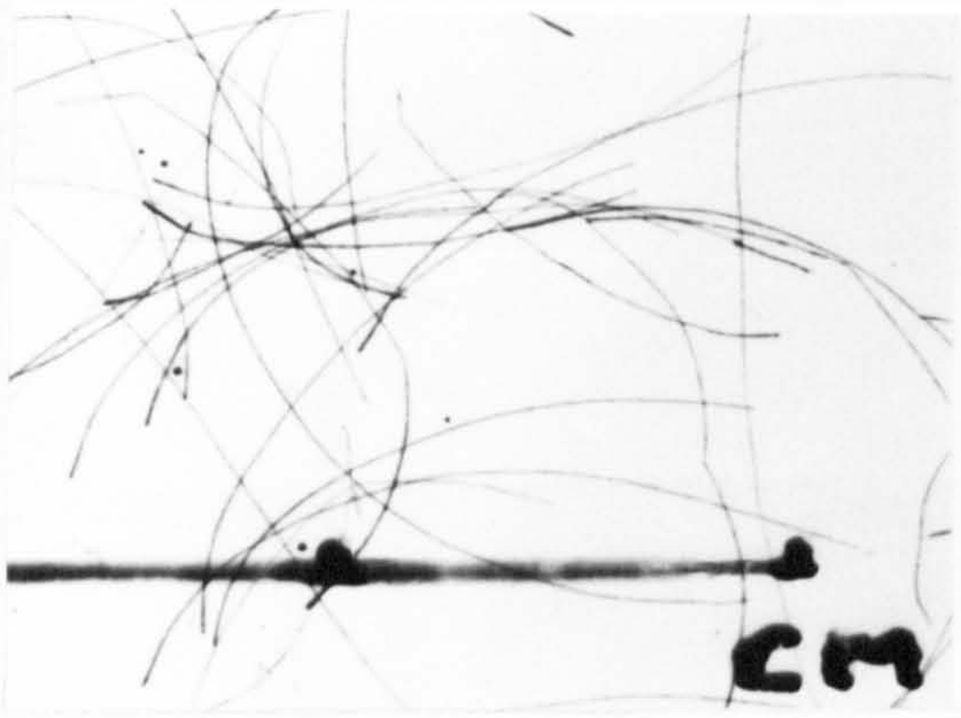
Fig.14: Whole mount and distal cross section of porcupine hair

Langur

a) External appearance:
   1. Colourless and transparent; neither white nor pigmented
   2. Fine and straight or slightly curved
   3. Generally greater than 3 cm in length

b) Cross section:
   1. Medulla commonly lacking
   2. Outline round, approximately 3 μ in diameter

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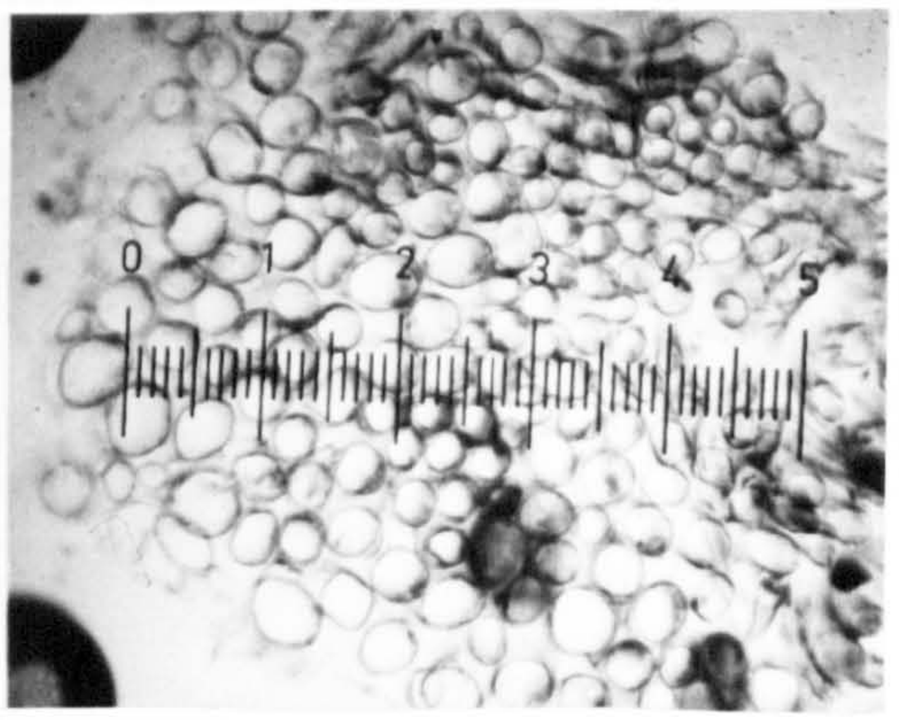


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Fig.15: Whole mount and cross section of langur hair

Wild boar

a) External appearance:
   1. Distal ends divided into two or more
   2. Hair pigmentation partially or entirely black (the latter being the more general case)
   3. Length rarely less than 2 cm
   4. Extremely coarse

b) Cross section:
   1. Medulla highly irregular (star shaped) and densely pigmented
   2. Hair outline oval, approximately 300 µ x 350 µ

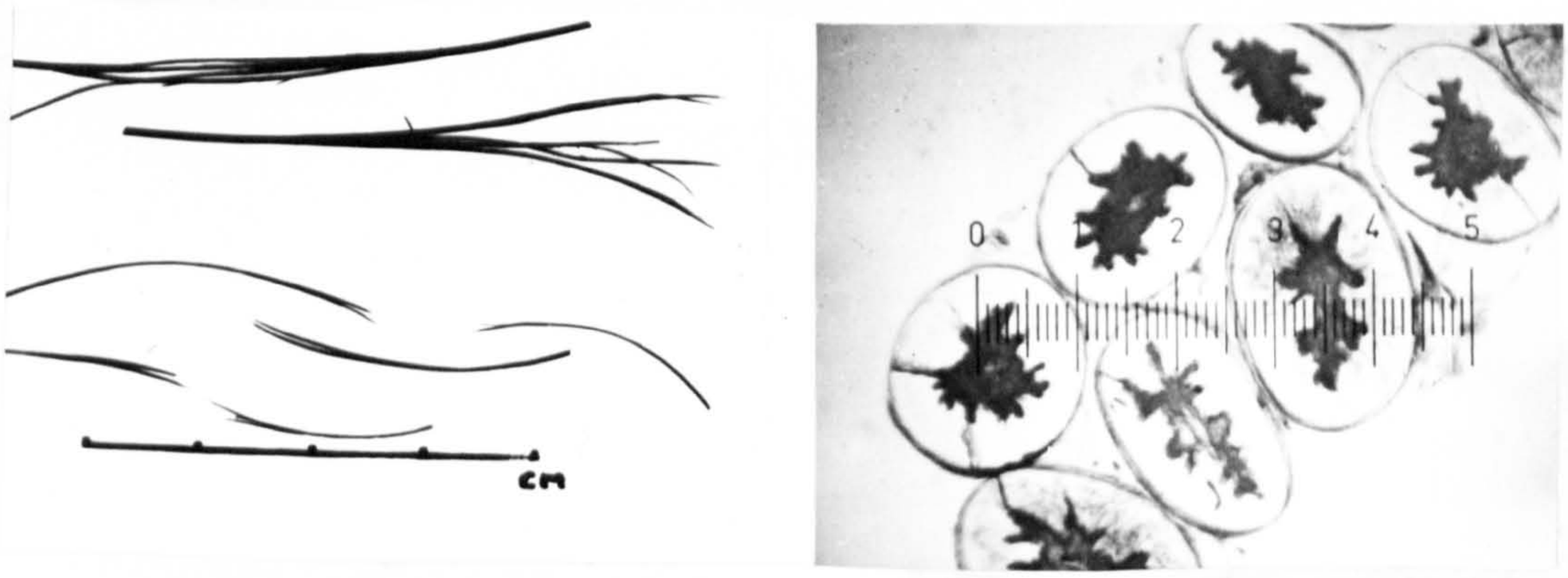


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Fig.16: Whole mount and cross section of wild boar hair.

Chital

a) External appearance:
   1. Abdominal hair white (unlike sambar)
   2. Hair of remainder of body generally dull brown or reddish-brown
   3. Generally less than 3 cm in length

b) Cross section:
   1. Outline oval to almost round. Less elongated than sambar
   2. Outline approximately 60 μ x 100 μ, or smaller
   3. Medulla occupies a conspicuously greater proportion of the cross section than does the cortex
   4. Medulla segmented, resembling sambar, but generally containing 20 or less segments

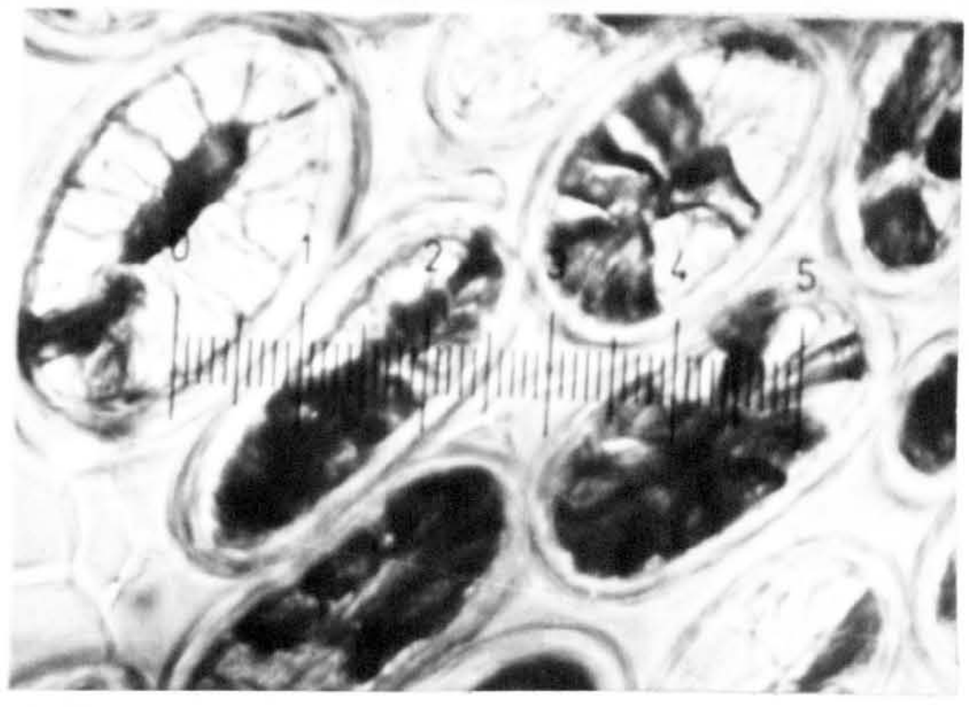

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Fig.17: Whole mount and cross section of chital hair

Sambar

a) External appearance:
   1. Pigmentation complete; dull brown or reddish-brown
   2. Rarely less than 4 cm in length
   3. Subtle numerous waves commonly, but not always, occurring throughout length

b) Cross section:
   1. Outline round to oval; commonly an elongated oval
   2. Outline approximately 200 µ x 500 µ
   3. Medulla occupies a conspicuously greater proportion of the cross section than does the cortex
   4. Medulla generally containing 30 or more segments
   5. Medulla segments black or nearly so

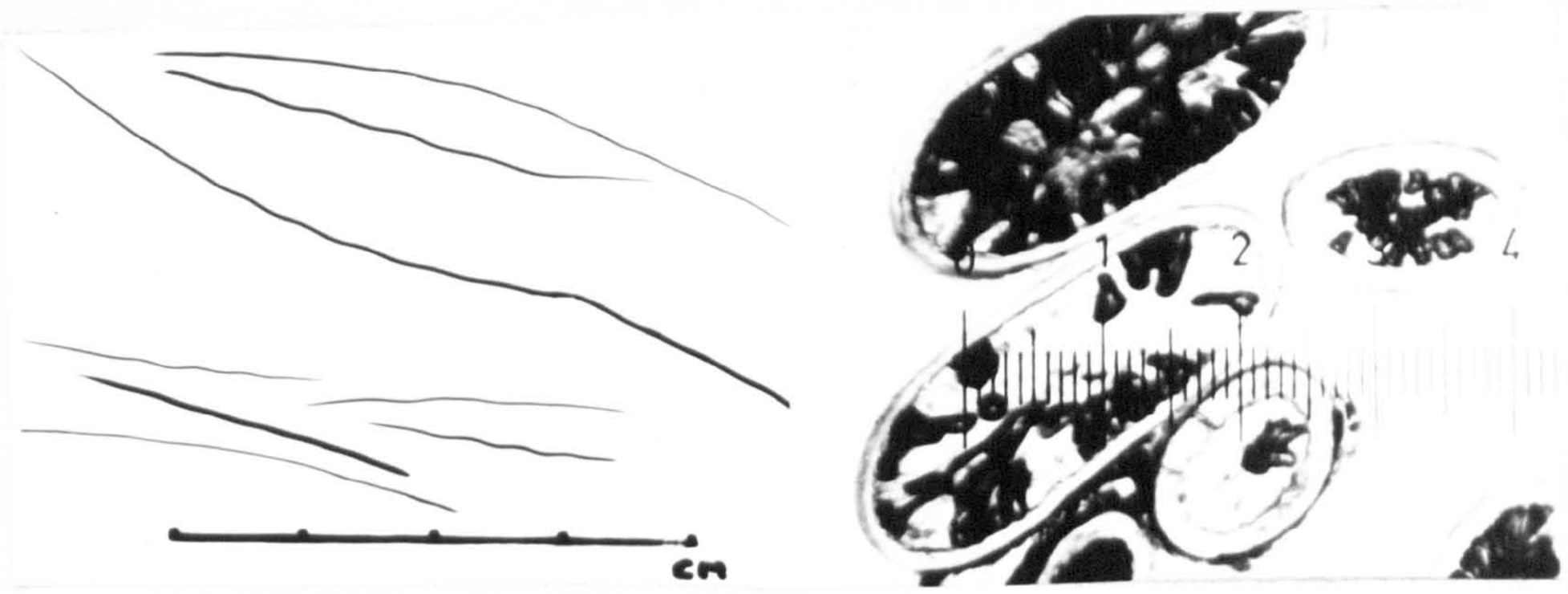


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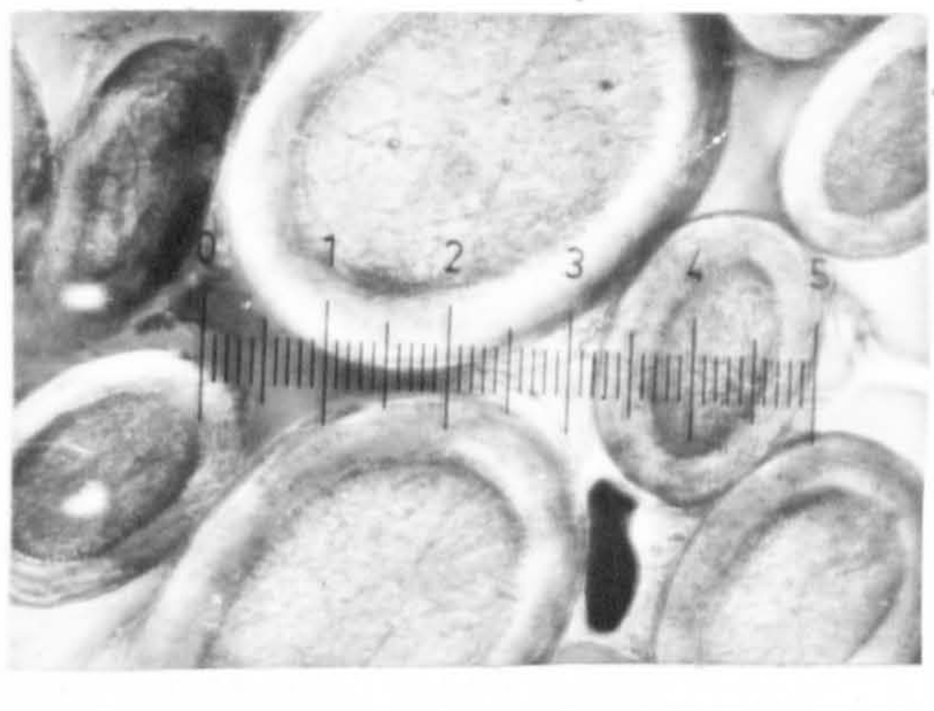
Fig.18: Whole mount and cross section of sambar hair

Four-horned antelope

a) External appearance:
   1. Abdominal hair white, remainder reddish-brown
   2. Length usually less than 3 cm
   3. Hair generally straight, slightly stiff

b) Cross section:
   1. Outline round to oval; approximately 70 µ x 80 µ
   2. Cortex width commonly less than one quarter the width of the medulla (unlike dog or lion hair)
   3. Medulla simple, granular, with light grey pigmentation.
   4. Reddish cortical pigment granules often conspicuous

Four-horned Antelope contd.

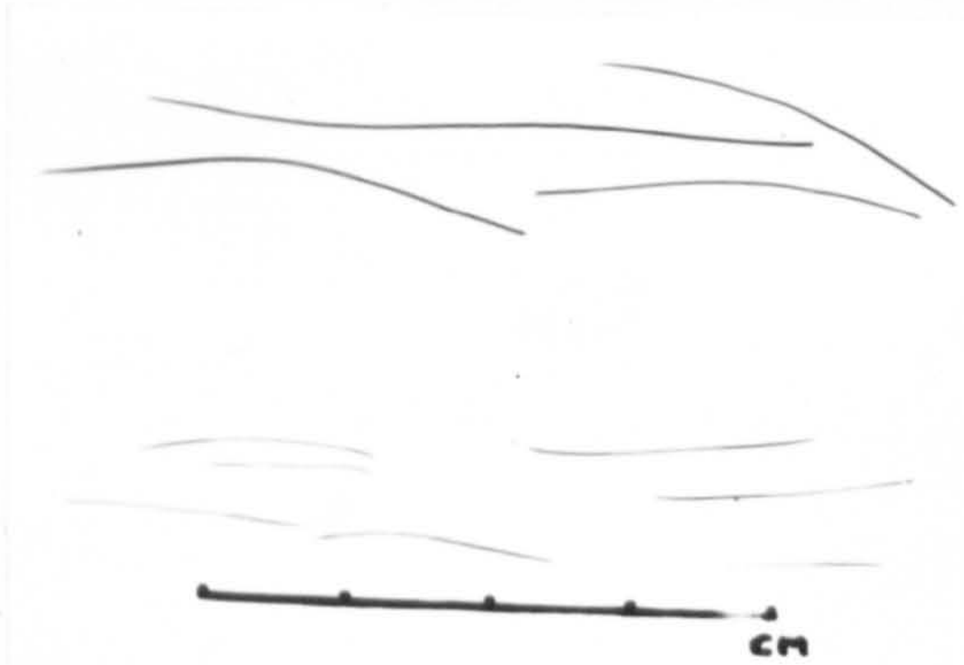

X 1.5 X 260

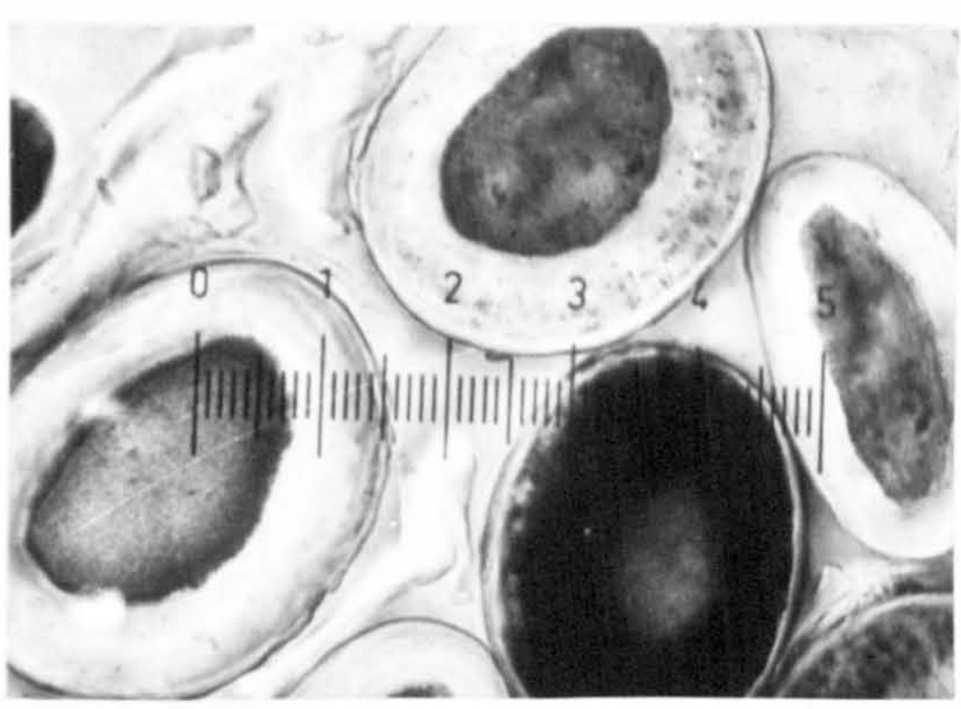
Fig.19: Whole mount and cross section of hair from Four-horned antelope

Nilgai

a) External appearance:
   1. Distal half black; proximal portion not pigmented or light brown
   2. Straight, slightly stiff
   3. Commonly 1.5 to 4 cm in length

b) Cross section:
   1. Outline slightly oval; approximately 100 µ x 135 µ
   2. Cortex either a homogeneous black, or containing reddish pigment granules
   3. Cortex width approximately one half the width of the medulla
   4. Medulla simple, granulated and dark grey
   5. Usually medulla partially flattened on one side, tending to be slightly pointed at each end



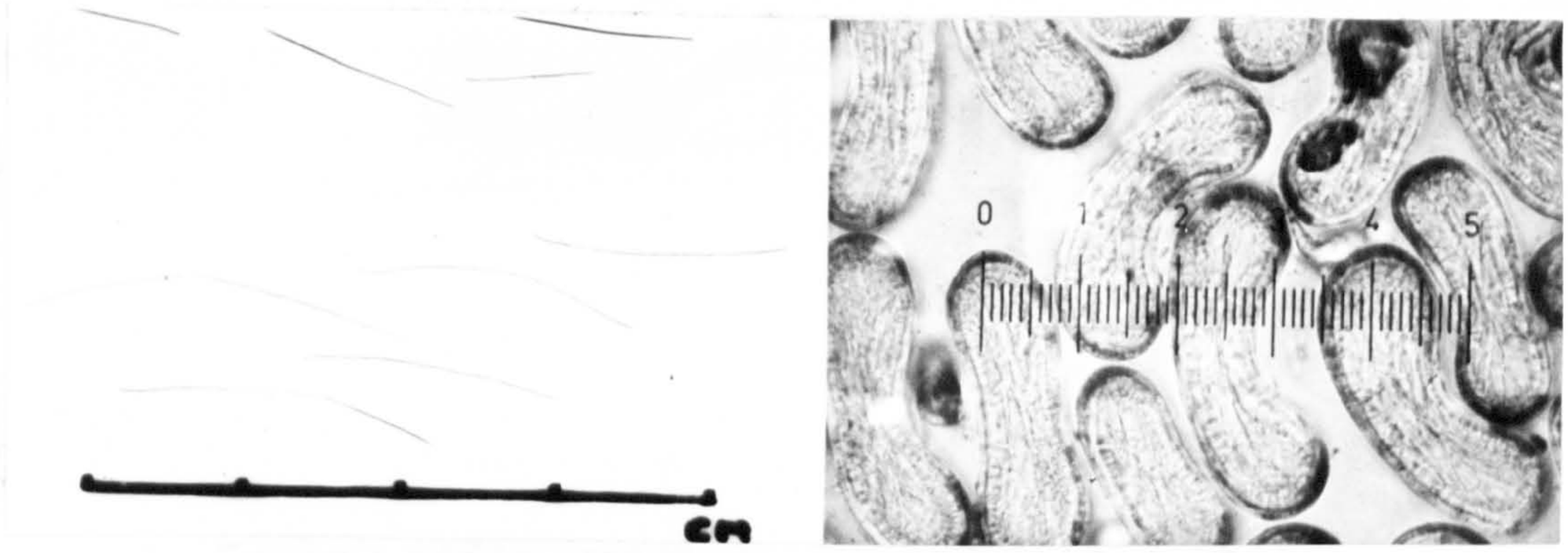

X 1 X 260

Fig.20: Whole mount and cross section of nilgai hair

Indian gazelle

a) External appearance:
   1. Hair straight or slightly curved, commonly 1 to 2 cm in length
   2. Abdominal hair white; hair from remainder of body light reddish-brown

b) Cross section:
   1. Outline bean shaped, slightly narrower across middle than across either end
   2. Outline approximately 30 μ x 110 μ
   3. Cortex thin in comparison with medulla
   4. In pigmented hairs the reddish cortical pigment granules are concentrated at the ends




X 1.4 X 260

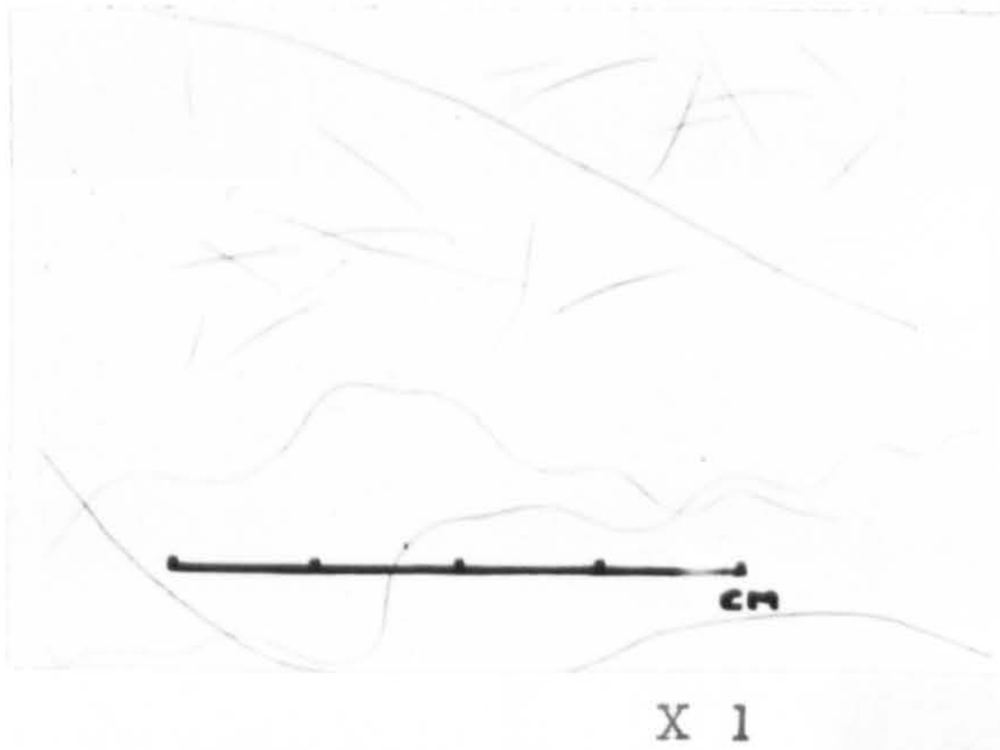
Fig.21: Whole mount and cross section of Indian gazelle hair

Lion

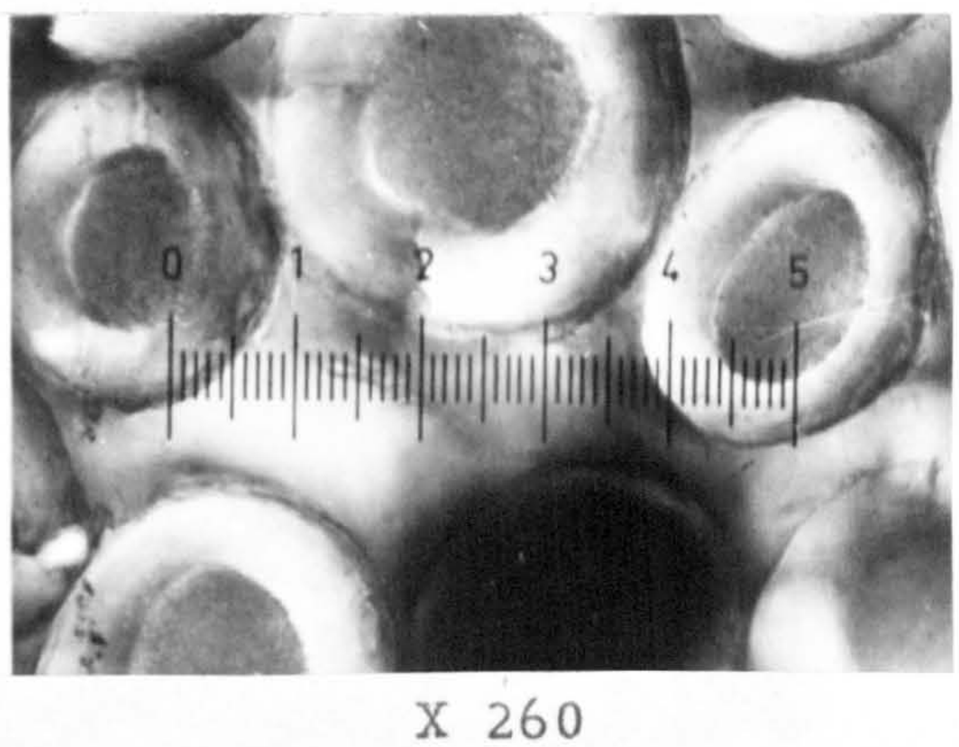
a) External appearance:
   1. Body hair usually white, straight or slightly curved, and commonly 1 to 4 cm in length
   2. Mane hair of variable colouration, commonly wavy, and approximately 10 cm in length

b) Cross section:
   1. Outline commonly round; approximately 80 μ in diameter
   2. Cortical pigment granules generally lacking in body hair (unlike dog hair)
   3. Cortex width equal to approximately half of the medulla width
   4. Medulla simple, granular and grey
   5. Medulla granules finer and more homogeneous than dog hair

Lion contd.




X 1




X 260

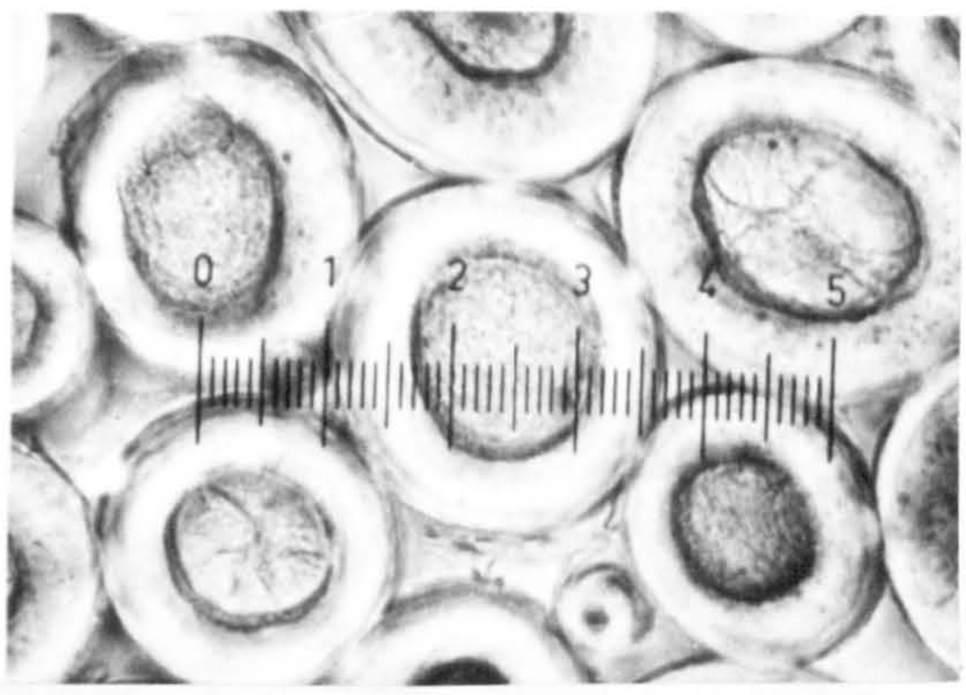
Fig.22: Whole mount and cross section of lion hair

Dog

a) External appearance:
   1. Wide variation in colour
   2. Commonly 2 to 4 cm in length

b) Cross section:
   1. Outline commonly round; approximately 80 μ in diameter
   2. Cortex width equal to approximately half of the medulla width
   3. Cortical pigment granules commonly observed
   4. Medulla simple, granular and grey


X 1



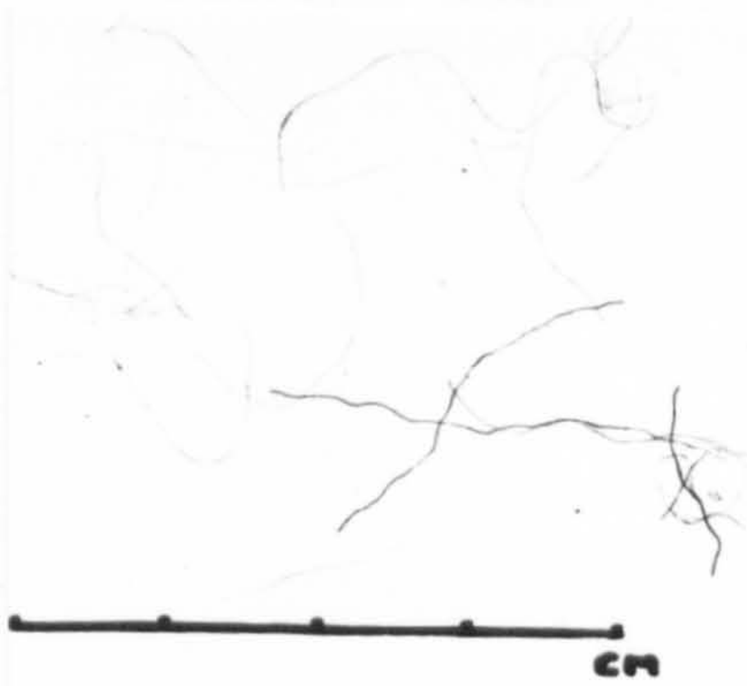

X 260

Fig.23: Whole mount and cross section of dog hair

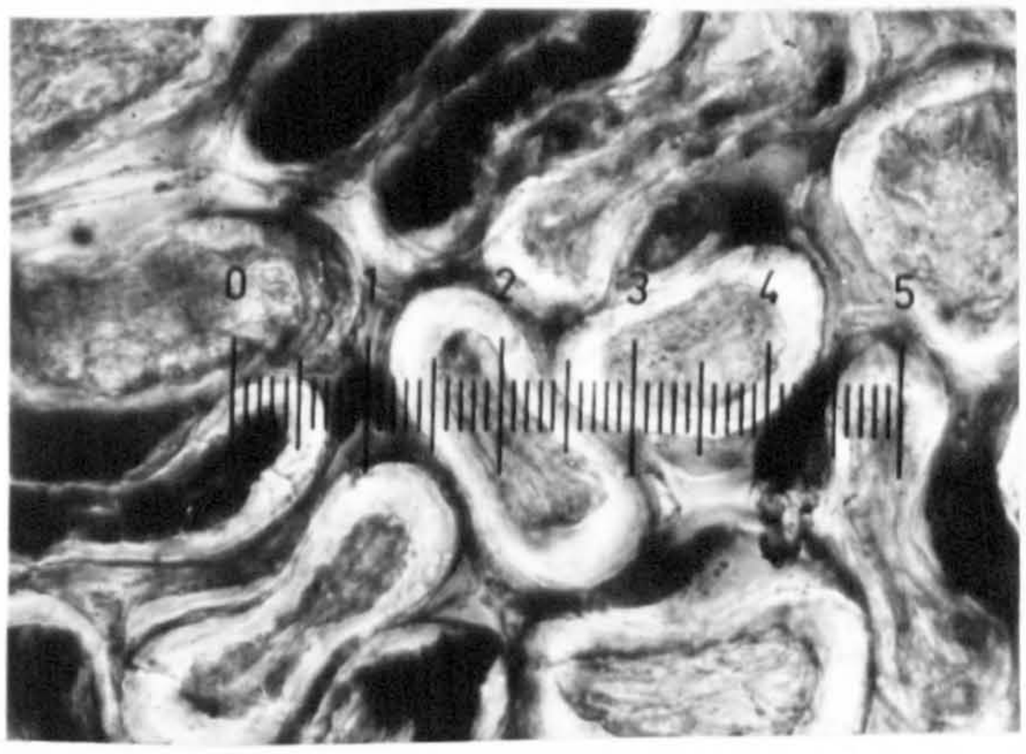
Sheep

a) External appearance:
   1. Shape of hair length irregular, tending to bind together; not straight or stiff
   2. Considerable variation in coarseness between hairs
   3. Lacking in pigment

b) Cross section:
   1. Outline irregular, rarely a perfect oval
   2. Outline approximately 35 μ x 100 μ
   3. Cortex lacking pigment
   4. Medulla grey or black, generally occupying most of cross section




X 1



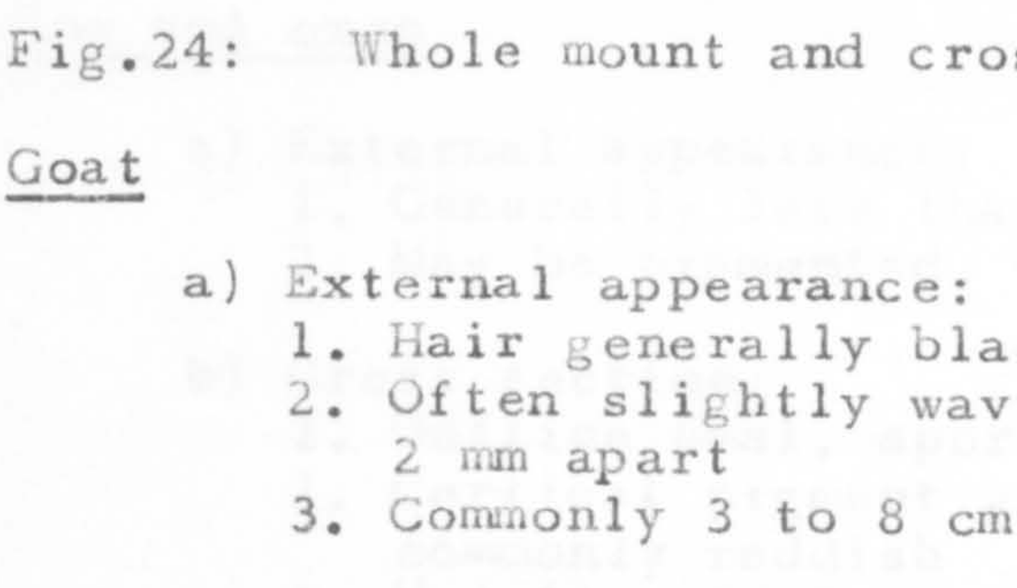

X 260

Fig.24: Whole mount and cross section of sheep hair.

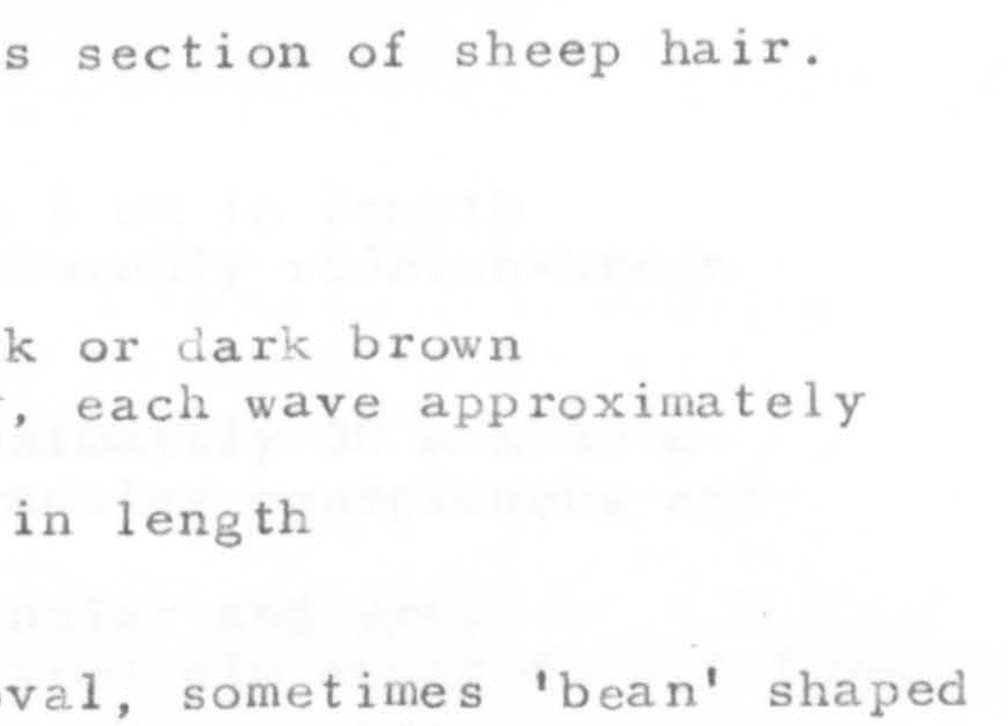
Goat

a) External appearance:
   1. Hair generally black or dark brown
   2. Often slightly wavy, each wave approximately 2 mm apart
   3. Commonly 3 to 8 cm in length

b) Cross section:
   1. Outline generally oval, sometimes 'bean' shaped
   2. Outline approximately 50 μ x 100 μ
   3. Cortex darkly pigmented; pigment granules large, clumped and purplish-blue




X 1



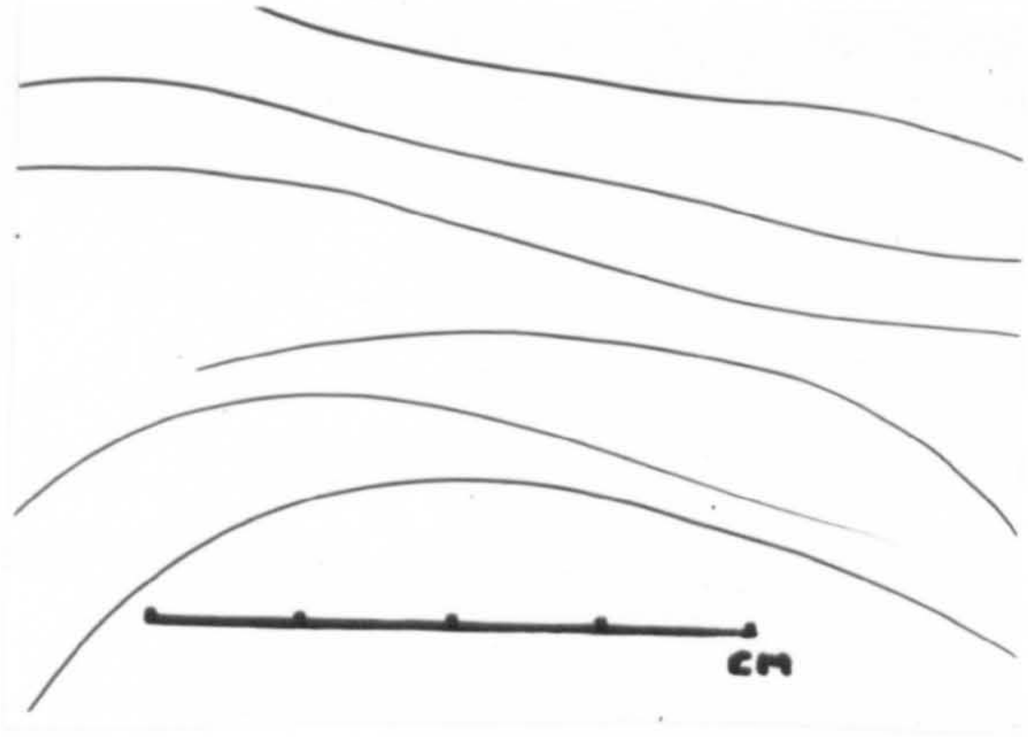
X 100

Fig.25: Whole mount and cross section of goat hair

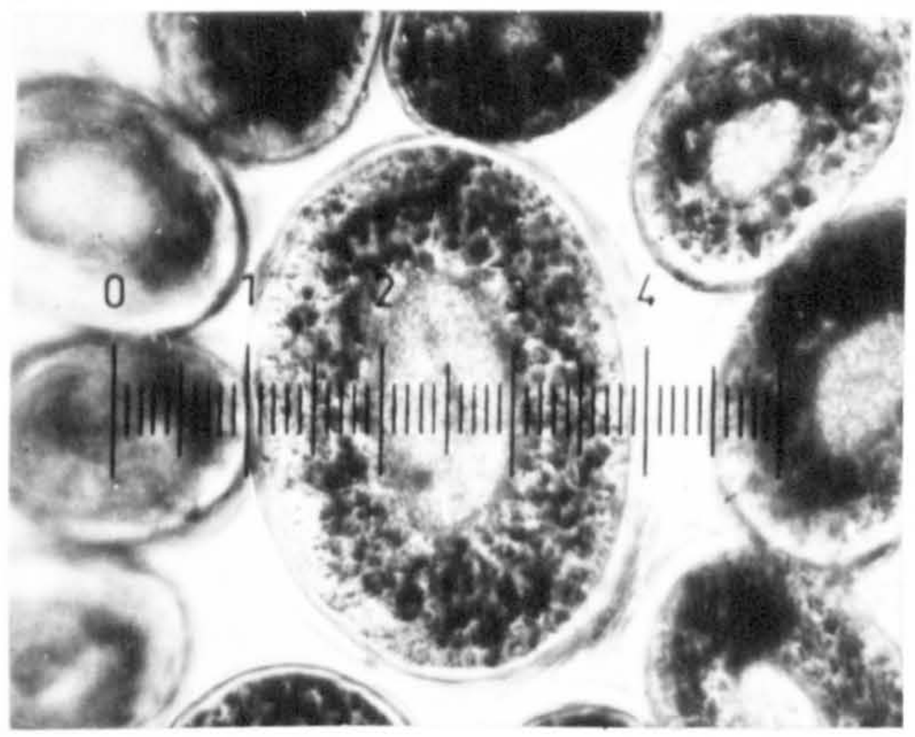
Buffalo

a) External appearance:
   1. Hair generally black or dark brown, and not wavy
   2. Usually greater than 10 cm in length

b) Cross section:
   1. Outline round to oval, approximately 60 μ x 90 μ
   2. Cortical pigment granules abundant, large, clumped and purplish-blue
   3. Cortex width approximately equal to medulla width
   4. Medulla simple, granulated and grey




X I




X 260

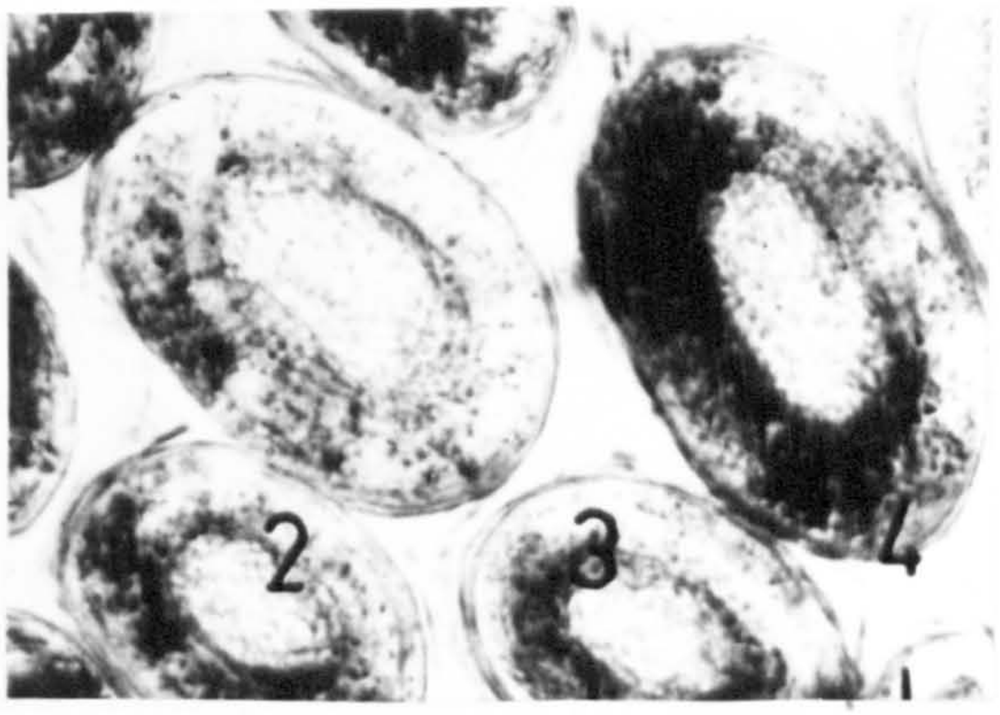
Fig.26: Whole mount and cross section of buffalo hair

Cow and oxen

a) External appearance:
   1. Generally less than 2 cm in length
   2. May be pigmented, commonly reddish-brown

b) Cross section:
   1. Outline oval, approximately 30 μ x 50 μ
   2. Cortical pigment granules conspicuous and commonly reddish
   3. Medulla simple, granular and grey
   4. Medulla width approximately equal to 1.5 times cortex width


X 1



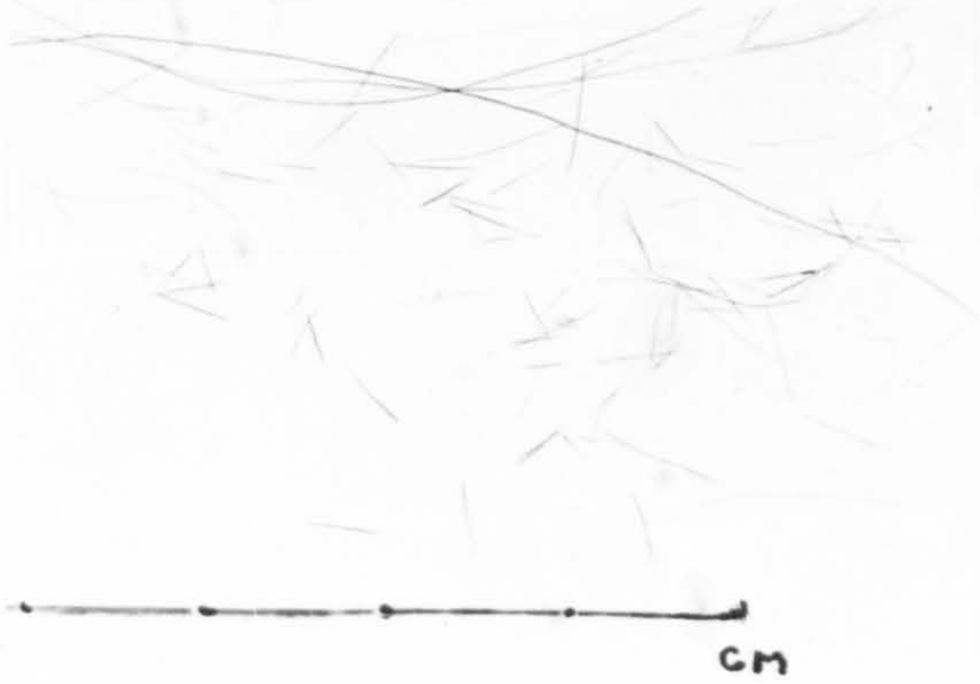

X 600

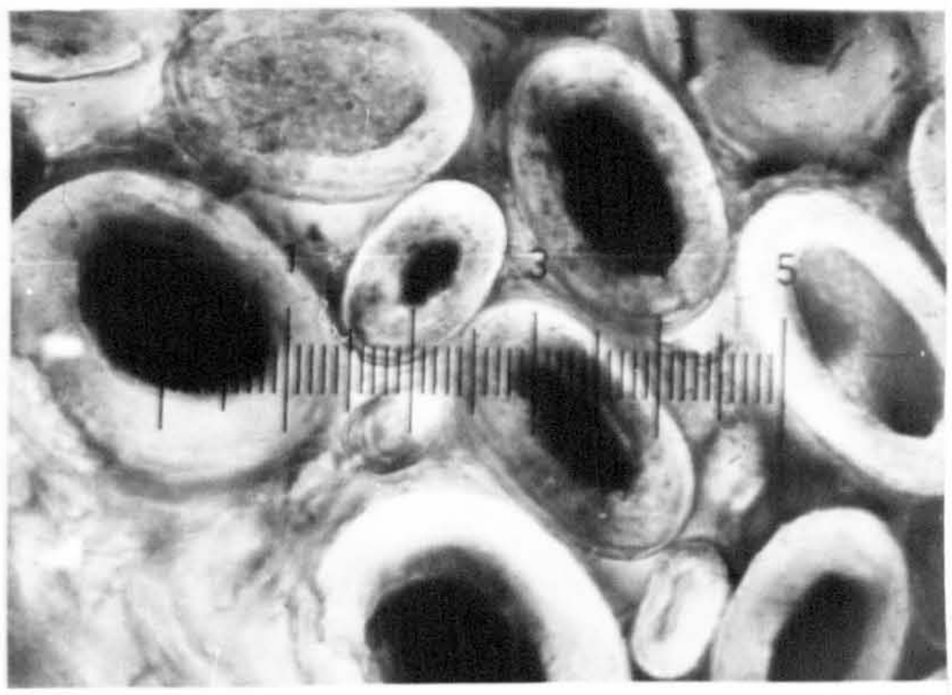
Fig.27: Whole mount and cross section of cow and oxen hair

Horse

a) External appearance;
   1. Hair length commonly less than 1 cm in length
   2. Hair straight or slightly curved

b) Cross section:
   1. Outline round to oval, approximately 50 μ to 80 μ
   2. Medulla simple, granular and densely pigmented
   3. Cortex granules often small



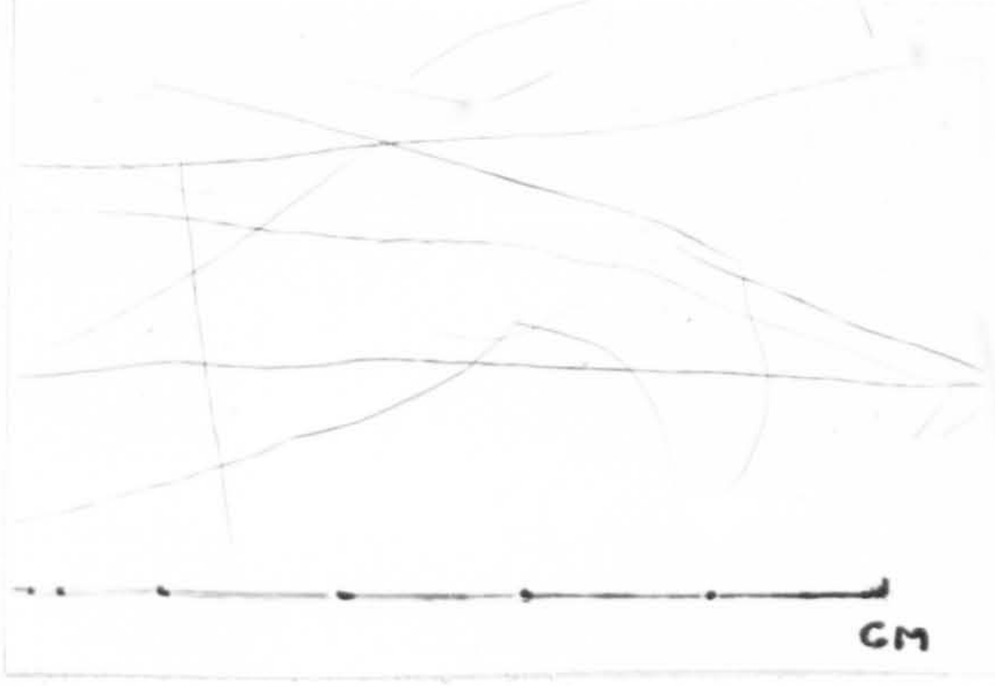
X 1.2 X 260

Fig.28: Whole mount and cross section of horse hair

Donkey

a) External appearance:
   1. Hair length commonly 2 to 5 cm
   2. Generally straight, often with subtle waves approximately 1 to 2 cm apart
   3. When pigmented, commonly reddish-brown

b) Cross section:
   1. Outline round to oval, approximately 70 μ to 90 μ
   2. Medulla simple, granulated and lightly pigmented
   3. Cortical pigment granules commonly numerous, clumped and reddish



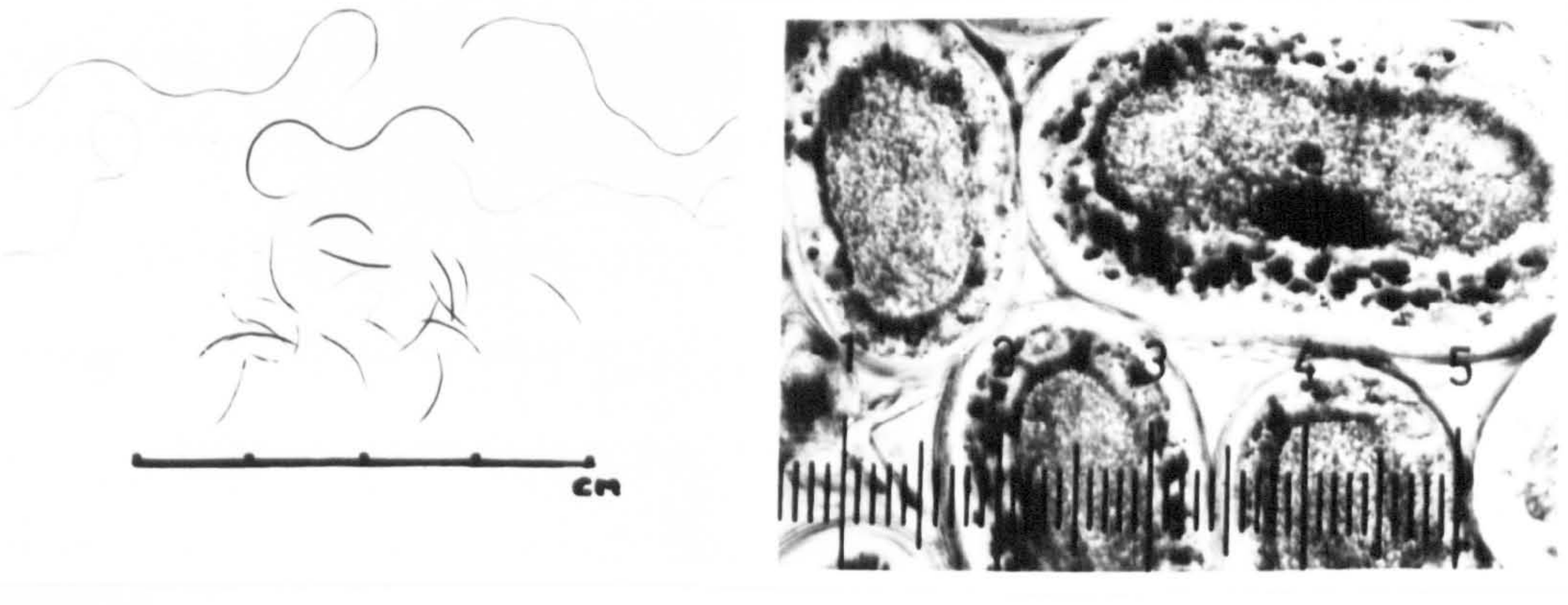

X 1.2 X 260

Fig.29: Whole mount and cross section of donkey hair

Camel

a) External appearance:
   1. Hair length either less than 1 cm and curved (not straight), or 3 to 4 cm with large waves
   2. Pigment reddish-brown

b) Cross section:
   1. Outline round to oval, sometimes parallel sided
   2. Outline approximately 50 μ x 120 μ
   3. Medulla simple, granular and either grey or black
   4. Cortical granules reddish, in conspicuous clumps




X1 X 400

Fig.30: Whole mount and cross section of camel hair.

## RESULTS AND CONCLUSIONS

Four hundred and eighty of 1884 scats were identified as lion scats from their diameter. They were collected in 1968-71 from outside the Gir sanctuary, in areas where known prides were commonly seen within the sanctuary, on the periphery of ranges used by known prides, and in other parts of the sanctuary. Numbers of scats collected in the different locations and the percent occurrence of domestic stock in each are given in Table 5. Outside the sanctuary wildlife was rare, so its lack of occurrence in the faecal samples was expected. Inside the sanctuary known lions in the central parts of their range were often given domestic stock, thus favouring the occurrence of domestic prey in their faecal samples. On the periphery of their ranges this influence was less, while outside the ranges of known prides it was non-existent. The results obtained were in the anticipated order, the probability due to chance being less than 0.05.

The scats from each area contained 75% or more domestic stock. However data collected on domestic stock killed by lions showed that lions ate nothing out of 24% of their kills (see p.89), and presumably ingested little hair, if any. Therefore lions probably killed a greater proportion of domestic stock than indicated by faecal analysis.

Only 88 of the 480 lion scats contained hair from wild ungulates. Chital appeared in 46% of the scats, sambar in 24%, wild boar in 22%, nilgai in 8%, four-horned

Table 5: Percentage occurrence of lion faeces containing hair of domestic stock collected from four areas

| Location | No. of scats collected | Domestic stock in each collection |
|---|---|---|
| Outside sanctuary | 19 | 100% |
| Areas of concentrated use by known prides | 141 | 83% |
| Periphery of range used by known prides | 96 | 80% |
| Other parts of the sanctuary | 224 | 75% |
| Total | 480 | |

antelope and gazelle were unrepresented. In Figure 31 the occurrence of each species in the faecal samples is compared with the estimated occurrence of each species in the wild. On the whole, faecal samples tended to reflect prey abundance. In detail, chital occurred proportionally less in the faecal samples than in the population, while wild boar and sambar had higher ratings. Because wild boar were easier than chital to approach undetected, and did not run as fast, they may have been more susceptible to predation. In addition to those faeces which contained hair of wild ungulates and domestic stock, 8 contained langur and 3 Indian hare.

The amount of hair which a lion ingested when feeding varied from species to species. Lions often ate considerable amounts of thinly haired hides of buffalo, but removed mouthfuls of hair and disgorged them before biting into the bodies of densely haired goats. When eating adult bovids, lions often ate only a portion of the hide and hair over the abdomen and anal region; but when eating calves they sometimes consumed most of the hide. These differences affected the quantity of hair present in each scat, but did not greatly bias the species representation in the faecal analysis because only presence or absence of each species was recorded in each scat. All scats contained some hair, and rarely more than one species in each.

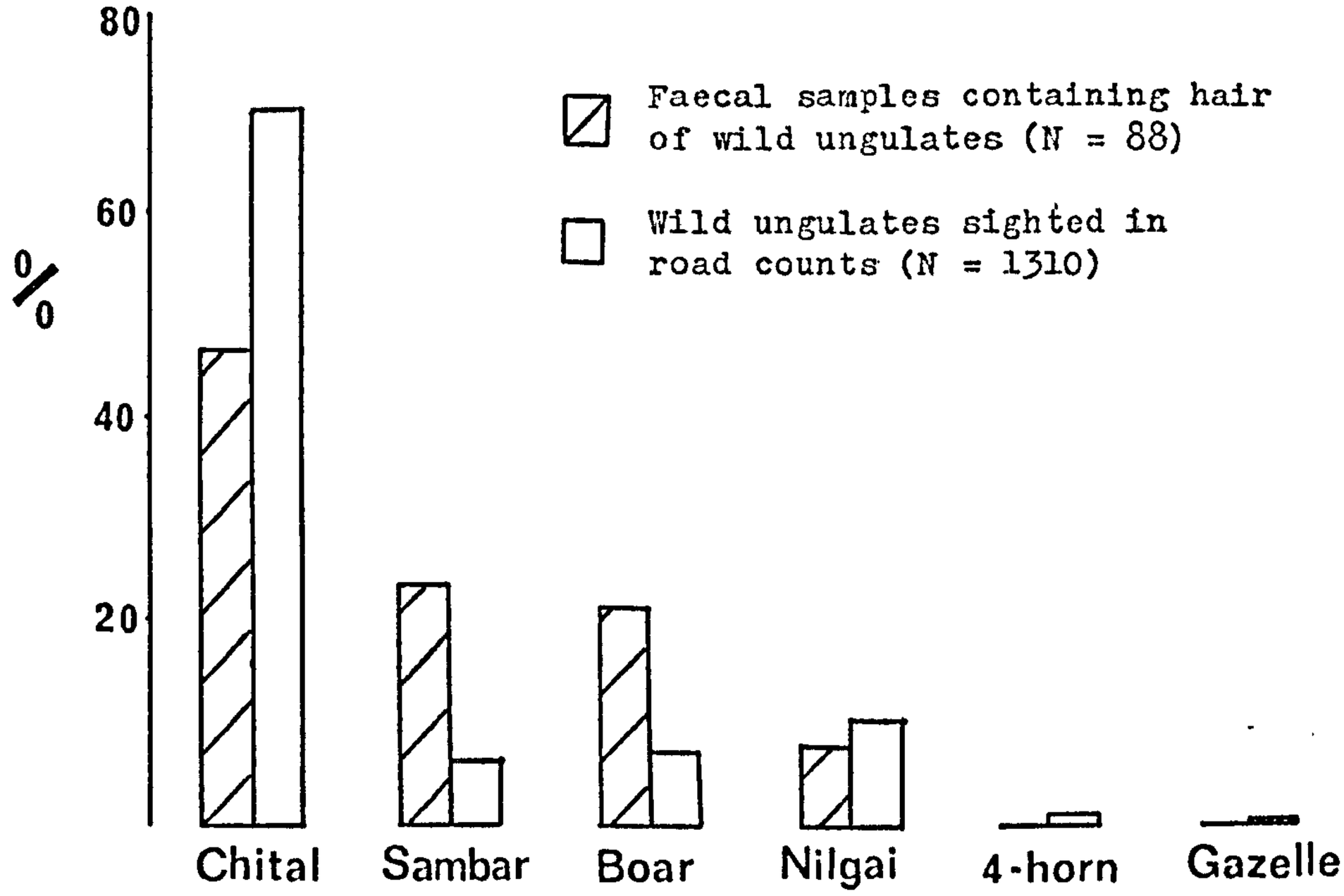



Fig. 31: Percentage occurrence of wild ungulates sighted during road counts in the Gir sanctuary, and present as hair in faecal samples of lions

# CHAPTER 7

# LION PREDATION ON DOMESTIC STOCK

## INTRODUCTION

I investigated the conditions under which lions killed and ate domestic prey. These included adaptations for prey catching in the day time, competition from people who scavenged hides and meat from carrion, and selection of prey according to age and sex. I did this because studies of prey numbers had established that the majority were domestic bovids, and the analysis of lion faeces had shown that lions ate mostly domestic bovids.

## METHODS

Field techniques: Rewards were offered to herdsmen over two years for cooperating in an inquiry into their losses of domestic stock. Ten rupees were paid to those who reported lion kills within 24 hours. Evidence, such as the nature and numbers of predators, how the prey was killed, whether eaten and to what extent, etc., was largely obtainable only during the first day after the kill, and in some cases only for the first few hours. This was because of disturbance to the kill and its environs by the activities of hide collectors, vultures, other scavengers and in some instances villagers and their stock. Speed in reporting and investigating kills was therefore essential.

Initially some 50 village headmen, mostly in the western half of the sanctuary, were informed of the reward scheme, and asked to spread the information. Because most herdsmen reporting losses could only do so on foot,

only those living in the western half of the sanctuary could reasonably be expected to reach me at the Sasan headquarters. To increase my coverage of the area I toured villages by jeep in the remainder of the sanctuary and surrounding lands, on the off chance of encountering reports of fresh kills. I also periodically shifted my headquarters within the sanctuary and employed other men to seek out kills at such times by going from village to village, and to report the location of any to me by the quickest means possible (truck, bus or bicycle).

Case histories were recorded on prepared forms (fig. 32). Predators were considered to be the cause of losses if the prey had deep tooth marks on the neck or claw marks over the back and sides.

To determine if lion or leopard I looked for their hair, tracks and faeces. Hair was often more easily found on the ground where the attack had taken place, rather than where the carcass had been eaten. Five to ten minutes were usually required to locate a few strands of hair, but sometimes none was recovered. Individual hairs that were white were assumed to be lion, while those that were black and white were identified as leopard. This method of classifying did not apply to adult male lions, which were identified by the presence of mane hair which was easier to find and was much longer than other hair.

Felid tracks having a length and width greater than

Fig. 32: Lion kill report similar to the one used in the assessment of herdsmen's losses in 1969-71

1. Name of owner_____;name of animal_____
2. Killed_____; injured_____
3. Species_____; sex_____; age_____
4. Location_____
5. Inside sanctuary_____; outside_____
6. Distance from village_____
7. Habitat_____
8. When killed_____; when seen_____
9. Composition of herd when attacked_____
10. Herd reaction when attacked_____
11. Herdsmen reaction during attack_____
12. Number killed_____; number injured_____
13. Neck bitten dorsally____; laterally____; ventrally____; not bitten_____
14. Evidence of strangulation_____
    neck haemorrhage_____
    neck broken_____
15. Number of lions seen by herdsmen_____
16. Lion evidence:
    number present_____
    tracks_____
    hair_____
    faeces_____
    carcass_____
    area of disturbance around kill_____
17. Carcass use: None____; 1-5 kg____; 6-10 kg____; half utilised_____
    fully utilised_____; estimated kg_____; unknown_____
18. Lions dragged carcass____; what distance_____; did not_____
19. Hide collectors came_____; have been called_____; from where_____
    when arrived_____; are not coming_____
20. Scavenger activity_____
21. Herdsman has applied or will apply for government compensation_____

REMARKS.

Where bitten, scratched, eaten:

200 mm were identified as lions (see p. 136 ). However, identifiable tracks were rarely found, either because the ground was not suitable for impressions or because the tracks had been destroyed by disturbance, as usually happened when the prey had been killed inside or beside a village. Faeces were found less often than tracks, and those with a bore diameter greater than 45 mm were assumed to be made by lion (see p. 46).

To determine how many lions had been present I examined the area of disturbance around the carcass, and the manner in which the carcass had been eaten. If the vegetation had been worn bare or trodden down for some distance, or several places of rest were identified, or if the carcass had been fed upon at several places, or if dismembered parts had been carried a few meters in different directions, there could be little doubt that several lions had been involved.

Occasionally hyaenas had been involved, and were detected by sightings, hair or tracks. Hyaena hair was distinctively long, like that of mane hair of adult male lions, but stiffer and coarser. Hyaena tracks were quite unlike either lion or leopard in shape.

I also recorded the location of kills, how far the prey was from village of origin, whether inside or outside the sanctuary, in what direction and how far dragged, whether fed upon, etc. If a carcass had been dragged there was usually a clearly defined trail of bent vegetation

sometimes 50-100 cm wide. The amount of food consumed was recorded by eye estimates which were sufficient to recog-:nise whether lions ate nothing, very little or a lot. Chewed bones were evidence of lions having fed if hide collectors and vultures had removed the flesh before my examination.

Some data were obtained from herdsmen who were present at attacks. I depended on them for information about how they and their herd behaved in an attack, about the time when it happened and the amount of the prey consumed. My records were sometimes incomplete because hide collectors, in severing the prey, masked the amount of damage done. However, if hide collectors preceded me, they or the herds-:men were sometimes able to report if lions had eaten nothing or some amount. The herdsmen told me if the hide collectors had been called when they were not present. The herdsmen also told me if they themselves were request-:ing payment from the government for their losses.

In order to test the herdsmen's reliability, most of the questions I asked were those for which I had already determined answers. These included: the type of pre-:dator, the approximate number, the number of stock, in some cases the herd composition, and whether hide collectors had come and gone, etc. I also made a habit of asking the same questions to more than one herdsman independently. On the few occasions when answers did not tally with my own findings, or differed between herdsmen, or I suspected in any way that a reply was false, then I regarded all of the

herdsmen's answers as suspect.

Data analysis: With the aid of a 360/50 computer, a systematic analysis of the data was made by associating each variable against each of the other 17 variables (Table 6). Some comparisons were omitted if they were obviously illogical. One hundred and twenty one cross-tabulations were constructed and levels of significance determined for each; those which yielded important differences were investigated further.

In some cases one variable was controlled while com-:paring the behaviour of two other variables. However I limited the number of such comparisons to those cases where I had some reason to suspect a pronounced correlation because the total number of tabulations was too numerous to investigate and because my data were often too limited to make controlling variables worthwhile.

RESULTS

Prey selection: Cow, buffalos and to a lesser extent oxen were attacked more often than other domestic prey. In a sample of 330 animals which had been attacked 40% were cows, 41% were buffalo, 13% were oxen and only 6% consisted of the combined totals of camel, sheep, goat, horse and dog. The latter five species were very much in the minority in the live population, so their poor representation in the kill record was to be expected. However, sheep, goat and dog were all small prey of little or no value to the herds-:men, and hence might not have been considered worth

Table 6: Correlations between factors influencing lion predation on domestic stock

$X^2$ tests:

\+ Probability less than 0.05

\- Probability more than 0.05

/ Test not made

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. | 17. | 18. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Condition of prey after attack (killed or injured) | | - | - | / | / | - | + | - | - | - | - | - | - | / | / | / | / | - |
| 2. Type of prey (cow, buffalo, etc.) | + | | - | - | - | - | + | + | + | + | + | - | - | - | + | + | - | |
| 3. Age of prey (adult, young) | - | - | | - | + | - | + | - | - | + | - | - | + | - | - | - | - | |
| 4. Numbers of prey killed during attack | / | - | - | | - | - | - | - | - | + | - | - | - | - | - | / | + | |
| 5. Numbers of prey injured during attack | - | - | + | - | | - | - | - | - | - | - | - | / | / | / | / | - | |
| 6. Location of killing bite (above or below neck, or elsewhere) | / | / | / | / | - | | - | - | - | - | - | - | / | / | / | / | - | |
| 7. Time when attack occurred (night, morning or afternoon) | + | + | + | + | + | + | | + | + | + | + | + | + | + | - | - | - | |
| 8. Distance from village of origin when attacked (inside village, edge, 150-400 m, etc.) | - | + | - | + | - | + | + | | + | - | + | - | + | - | + | | + | |
| 9. Inside or outside the sanctuary when attacked | + | + | - | - | + | - | + | + | | - | - | + | - | + | - | - | | |
| 10. Origin of prey (sanctuary village, forest settlement village or village outside sanctuary) | + | + | + | + | - | + | + | - | - | | + | + | + | + | + | + | + | |
| 11. Herd composition (all cows, all buffalo, etc.) | + | + | / | / | / | / | + | + | + | + | | + | + | / | / | / | / | |
| 12. Herd response when under attack (aggressive or retiring) | + | - | / | / | / | - | + | - | - | - | - | | + | - | / | / | / | |
| 13. Herdsman response during attack (attempted to drive lions away or did not) | + | - | / | / | - | + | - | - | - | - | - | - | | + | - | / | / | |
| 14. Food utilisation (lions ate nothing, a little or a lot) | + | + | / | + | + | + | + | + | + | + | + | + | + | | + | / | + | |
| 15. Carcass movement (lions dragged it away or did not) | + | / | + | + | / | + | + | + | + | + | + | + | - | + | | / | + | |
| 16. Appropriation of dead prey by hide collectors (Did or did not) | - | - | - | - | - | - | - | - | - | + | + | - | - | + | / | | / | |
| 17. Herdsman claiming for government compensation to cover his loss (yes or no) | - | - | - | / | - | - | - | + | - | + | + | - | - | / | / | / | | |
| 18. Lion group structure during or following attack (one lion, more than one, cubs also present) | - | - | - | + | - | - | - | - | - | + | + | - | - | + | + | / | | |

reporting (although I paid an equal reward for all cases investigated). It was illegal to graze sheep within the sanctuary, which may have contributed to there being no reports of sheep loss.

Sixty-one percent of bovid kills were from sanctuary villages, 25% from villages outside the sanctuary, and 14% from forest settlement villages. Stock from sanctuary villages remained inside the sanctuary, and hence were always available to lions, while stock from outside villages came into the sanctuary for only variable parts of each day, and never at night, thus accounting for their poor representation among lion kills. Few animals were from forest settlement villages probably because they contained only 10% of the available prey population.

The three village classes also kept different proportions of cows, oxen and buffalo. To determine the lions' food preferences, I compared the kill records with the bovid stock available from each village class. While predation always reflected prey abundance to some extent, cow and ox were preferred over buffalo in all three village classes (fig.33). The probability of obtaining such a result three times due to chance was less than 0.02. Averaging the results for the three village situations, twice as many cows and oxen were killed as would have been expected if they were killed directly in proportion to availability, while the proportion of buffalo in the kill was less than half that expected.

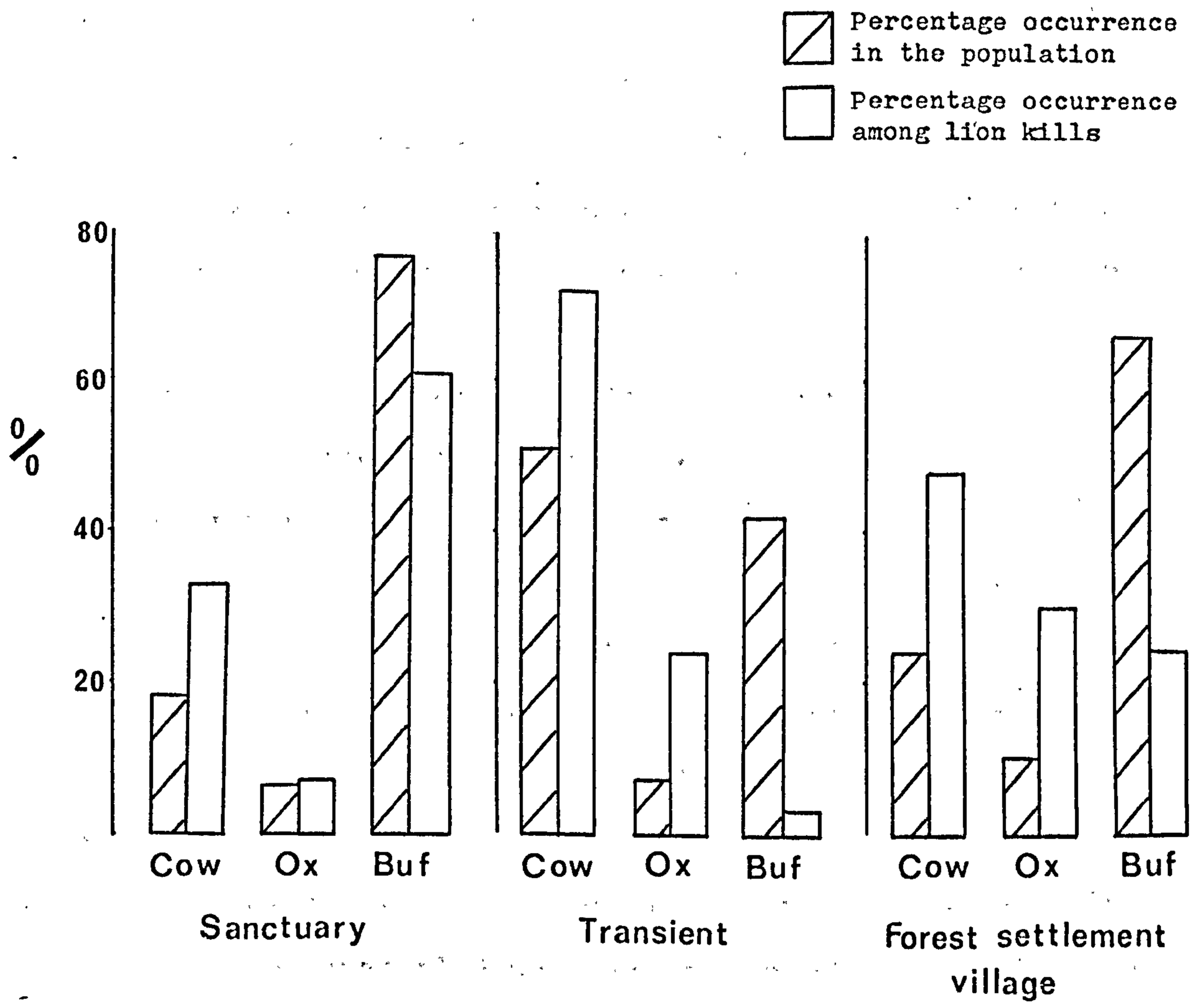



Fig. 33: Lion selection of prey from three classes of livestock

There was evidence that cow and ox were more vulnerable than buffalo. First, their placement within the herd was at greater risk to predation. Miss Dorothy Brewster (pers. com.) collected data on the position of cow, buffalo and herdsmen within herds. In a total of 27 observations she found that adult cows predominantly occupied the front of the herd in 61%, buffalo occupied the middle and rear in 81%, and herdsmen occupied the middle and rear in 93%. In other words adult cows were located where the protective influence of the herdsman was weakest. Moreover cow and ox herds normally fled when attacked, while buffalo herds were commonly belligerent towards lions, sometimes succeed-:ing in driving them away before the herdsman came to their rescue. Ninety-seven per cent of 32 herds consisting only or mostly of cows were reported to have fled when attacked, while 56% of 75 herds consisting only or mostly of buffalo behaved aggressively. Seven of 8 herds consisting only or mostly of oxen fled when under lion attack. While ox thus appeared to exhibit little defence, these data were too few to be conclusive. However, it was further sub-:stantiated by 96% of 24 herds containing mostly cows and some oxen, which fled when under attack.

Age selection: Thirty-seven per cent of 240 kills of bovid stock examined for age were young animals less than five years old. The true proportion of young animals killed was probably higher because herdsmen valued mature animals more highly, and were more likely to report their

loss, despite an equal reward offered for the report of kills of any age. In sanctuary villages 41% of the live bovid population and 35% of kills were young stock.

More young were available inside villages than outside, and this was reflected in 20% more young killed inside villages than outside (N = 240; $X^2$ = 4.47; d.f. = 1; $p < 0.05$). Lions killed approximately 20% more young among buffalo than among cows. The same pattern emerged no matter whether the losses were from villages inside or outside the sanctuary (fig.34). Lions also killed c 40% more young among oxen than among buffalo (N = 126; $X^2$ = 6.44; d.f. = 1; $p < 0.05$), excluding those cases where oxen had been left alone overnight outside villages. Under such favourable conditions lions killed all stock regard-:less of prey type or age. A disproportionate number of adult oxen had been left out overnight, while only an insignificant number of buffalo and cows had been left out.

As noted above, buffalo were more difficult to kill than cows. Similarly young buffalo were preferred over adult buffalo. The selection of young oxen, however, was largely due to their greater availability. In daytime most adult oxen were employed outside the sanctuary either as plough animals or to draw carts.

Time of attack: In the 24 hour cycle there were two peaks in the numbers of prey attacked. Twenty-three per cent of attacks occurred between 0630-1130 hrs and 33% between 1530-1930 (fig.35). A number of factors accounted

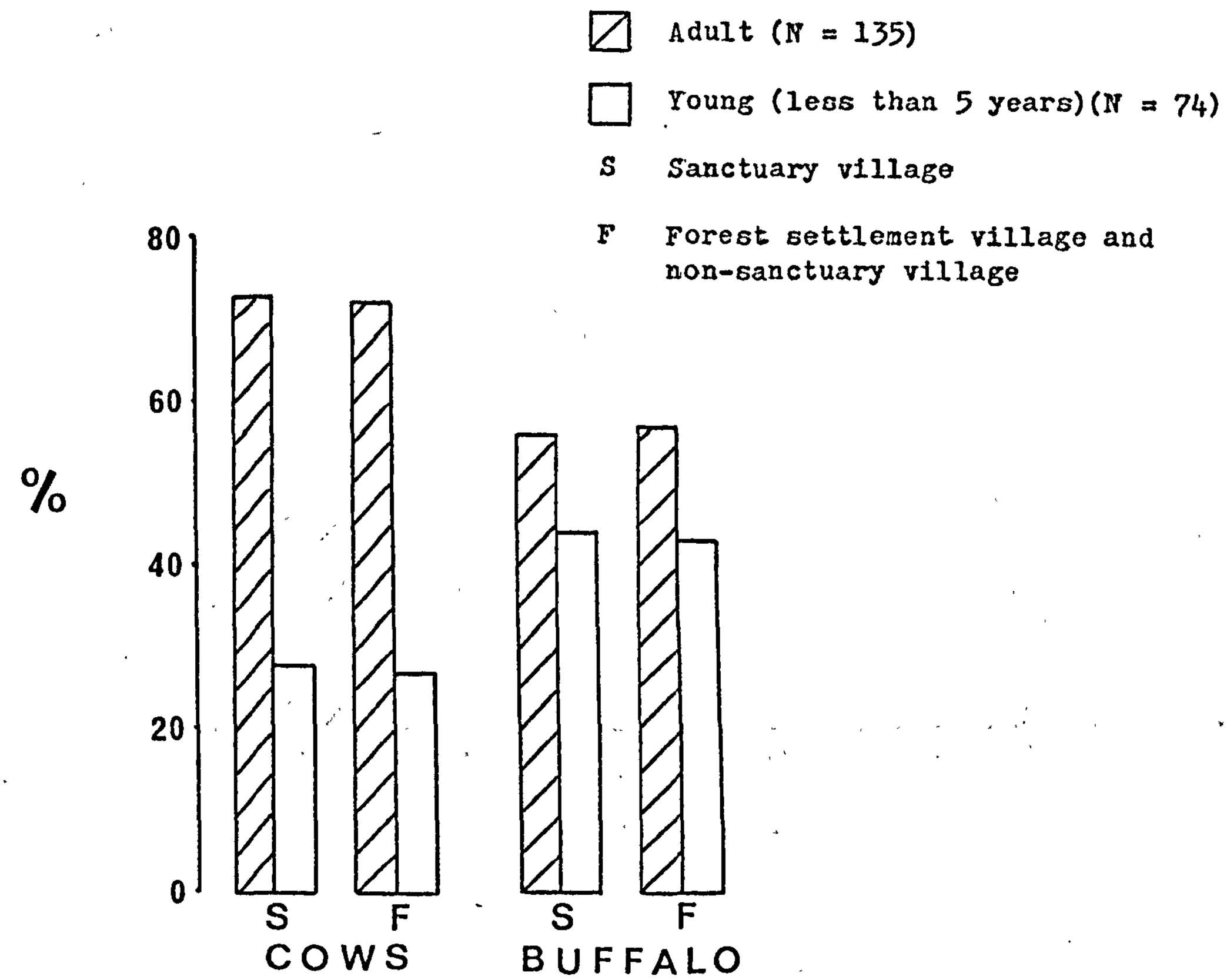



Fig. 34: Percentage occurrence of adult and young stock among lion kills from two village classes (S and F) and for two types of prey

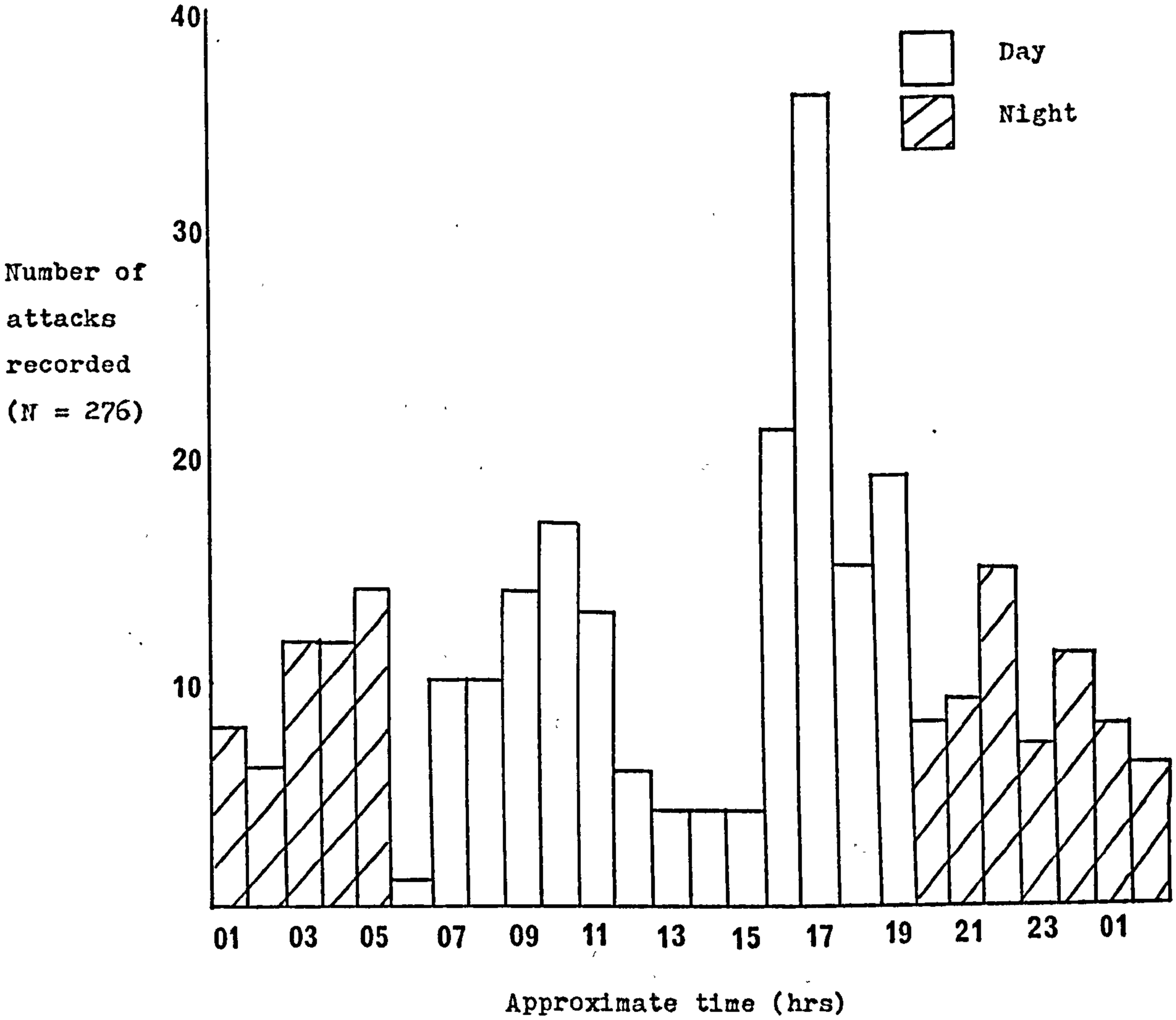



Fig. 35: Number of lion attacks upon domestic stock during each hour of the 24 hour cycle, as reported by herdsmen

for these peaks. In the morning there was a build up in attacks, starting from a minimum at c 0600 hrs and increas-:ing to a maximum by 1000 hrs. This was associated with the increase in the number of animals grazing in the sanctuary. Few attacks were made between 1130-1530 hrs, when the combination of high air temperatures and direct exposure to the sun was most severe. On those attacks which occurred between 1130-1530 hrs, all but one took place either in the monsoon or early in the cool season, when daytime temperatures were moderate (less than 29'C). In the hot season most lions rested in shade through the middle of the day. The herdsman also contributed to the lack of contact between predator and prey by resting their stock for approximately 2 hrs during that time.

Between 1530-1730 hours there was a dramatic build up in numbers of attacks, followed by an appreciable decline over the next 3 hrs. At the same time the pattern of activities which paralleled the morning's peak were repeated in reverse. Lions stopped resting and livestock again grazed, then returned to their village of origin, which in many cases was outside the sanctuary.

Fifteen per cent more animals were attacked in the shorter afternoon peak than in the morning, the possible reasons for which were varied. Lions consumed more of what they killed in afternoons because of less competition

with hide collectors. Stock were also taken out to graze in the morning only after daylight, while some stock did not return until dusk, when reduced visibility made the animals more vulnerable to attack. Stragglers were more apparent in herds by mid afternoon than in the morning, and perhaps were not given all the due care and attention by the herdsman who were tired and anxious to return home. It was also apparent that herdsmen allowed their stock less time to graze in the afternoon, and instead kept them moving. This both increased the likelihood of a lion encounter and made conditions more unfavourable for stragglers attempting to keep up.

Only 39% of attacks were made at night (c 1930-0530 hrs). These included 11 night attacks not recorded in figure 35 because the herdsmen did not know at what hour the attack occurred. Lions were much more active at night. However, their domestic prey, which had moved about the sanctuary in daytime, was confined to village corrals at night. Only by entering the periphery of villages was it possible for lions to make an attack at night. Secondly, before any animals could be attacked, lions had to penetrate either thorn scrub fencing or rock walls which had been used as corral material specifically to prevent predation (fig. 36 and 37). And thirdly, much of the stock which had grazed within the sanctuary in the daytime was unavailable at night because it had been taken to villages outside the sanctuary

Fig.36: Thorn scrub fencing: Prodigious amounts of thorn scrub fencing were used to corral livestock within sanctuary villages, in order to protect against lion predation. Entire acacia trees, such as the one in the foreground, were sometimes used to block corral entrances at night.

Fig.37: Stone fencing: Non sanctuary villages and forest settlement villages used predominantly stone fencing for corralling livestock.

Within villages the fewest night attacks occurred between 1930-2030 hrs, presumably because herdsmen were not yet bedded down for the night. Some stock were also attacked outside villages at this time because a few herdsmen were late in returning their stock from grazing. No pattern was discernible among attacks in the remainder of the night. However this may have been because herdsmen were unable to estimate the time of attacks at night with much accuracy unless they occurred early.

Location of attack: Records of 251 lion attacks were analysed in relation to distance from villages from which the prey had come. Eleven percent were inside villages, 10% within 150 m of the village margin, 16% between 150-400 m, 31% between 400-1000 m, 12% between 1000-2000 m, and 19% at over 2000 m. When 52 injured animals were examined in relation to distances from village of origin, a similar pattern emerged to that for lion kills (fig.38). However there were very great differences between night and day, which reflected the availability of prey at those times (fig.39). At night 76% occurred within 400 m, while a number of those which took place at greater distances had been driven out of villages by lions. In contrast no day kills occurred within villages and 11% between village edges and 400 m. The bulk of day kills (52%) took place within 400-1000 m, and consisted mainly of sanctuary village and forest settlement village stock. Mary Ann Berwick (pers. com.) has shown that sanctuary village herdsmen graze their stock within an average 1300 m of sanctuary villages in the dry

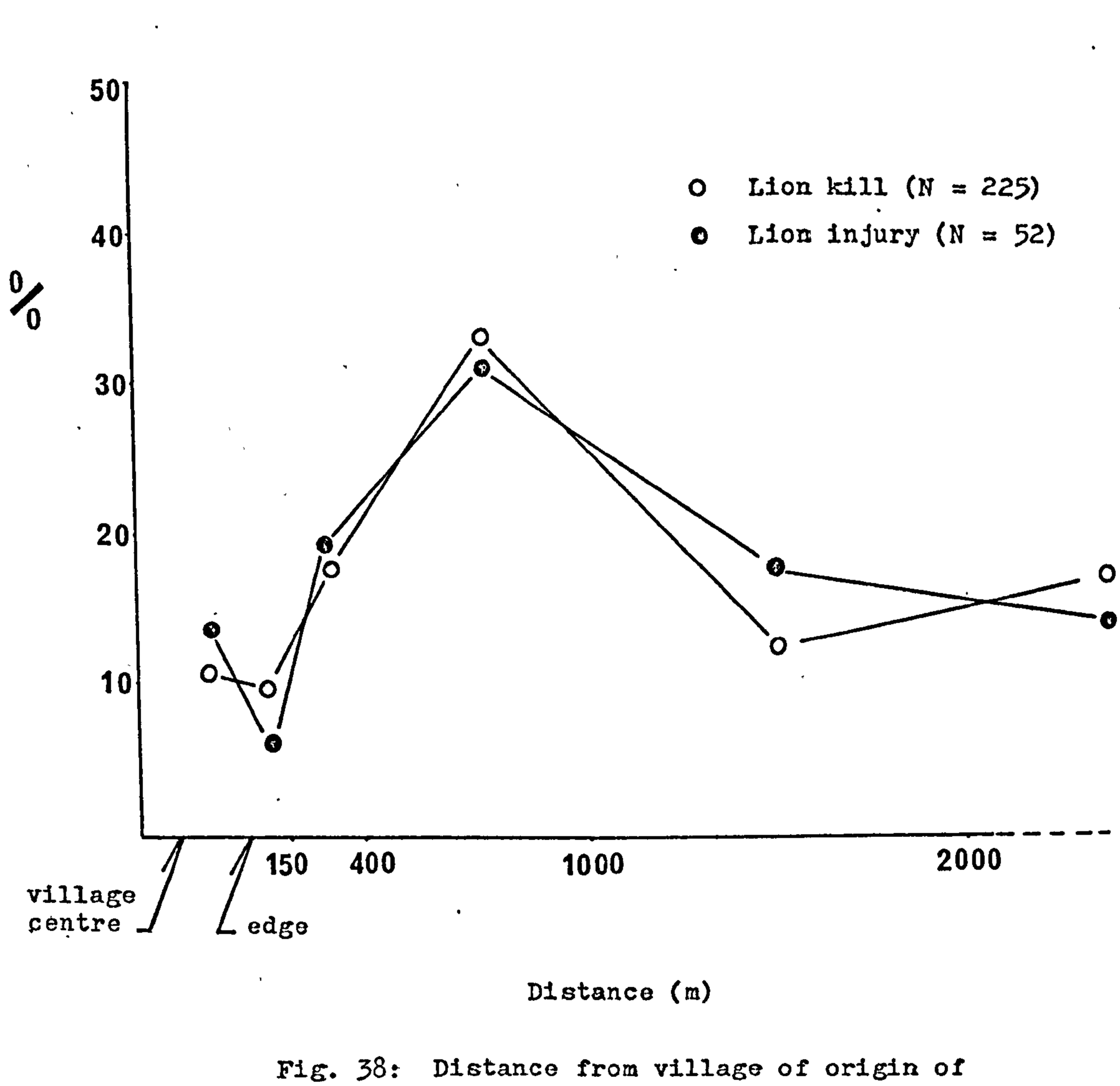



Fig. 38: Distance from village of origin of stock killed and injured by lions

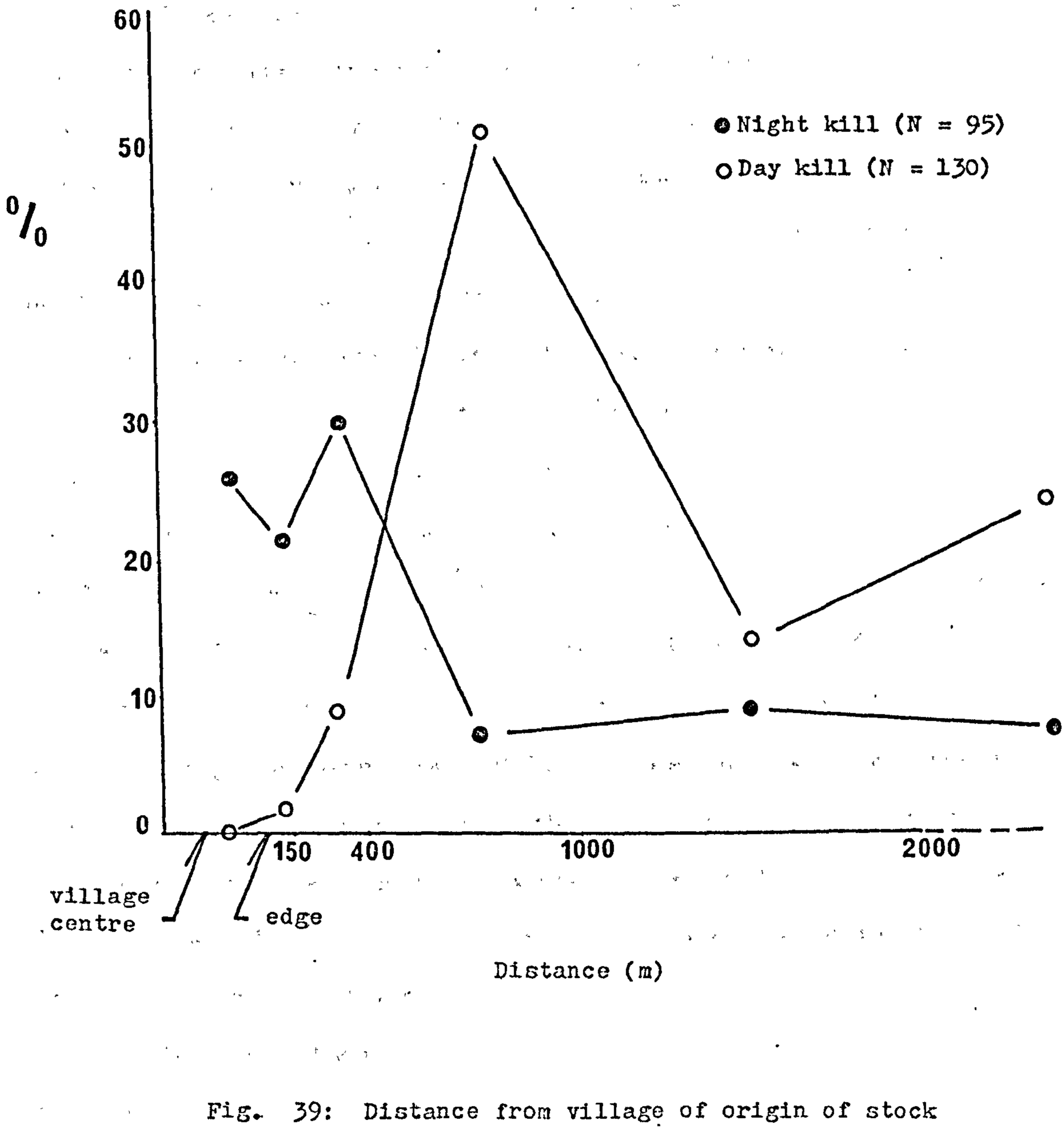



Fig. 39: Distance from village of origin of stock killed at night and during the day

season. This would account for the preponderance of day kills at relatively short distances. In contrast, the majority of 24% of stock killed beyond 2000 m had come from villages outside the sanctuary. Many outside villagers had to travel 1-2 km just to reach the edge of the sanctuary.

Food consumption: Although 74% of kills were reported to have involved more than one lion, the meat available was poorly utilised. In a sample of 173 kills lions ate nothing from 24% and 1-10 kg from c 22% (Table 7). Lions ate less from prey killed at night. They ate nothing from 41% of night kills, 19% of kills made between sunrise and noon, and 2% of kills made between noon and sunset. Lions ate more than 10 kg from 11% of night kills, 30% of morning kills, 45% of afternoon kills.

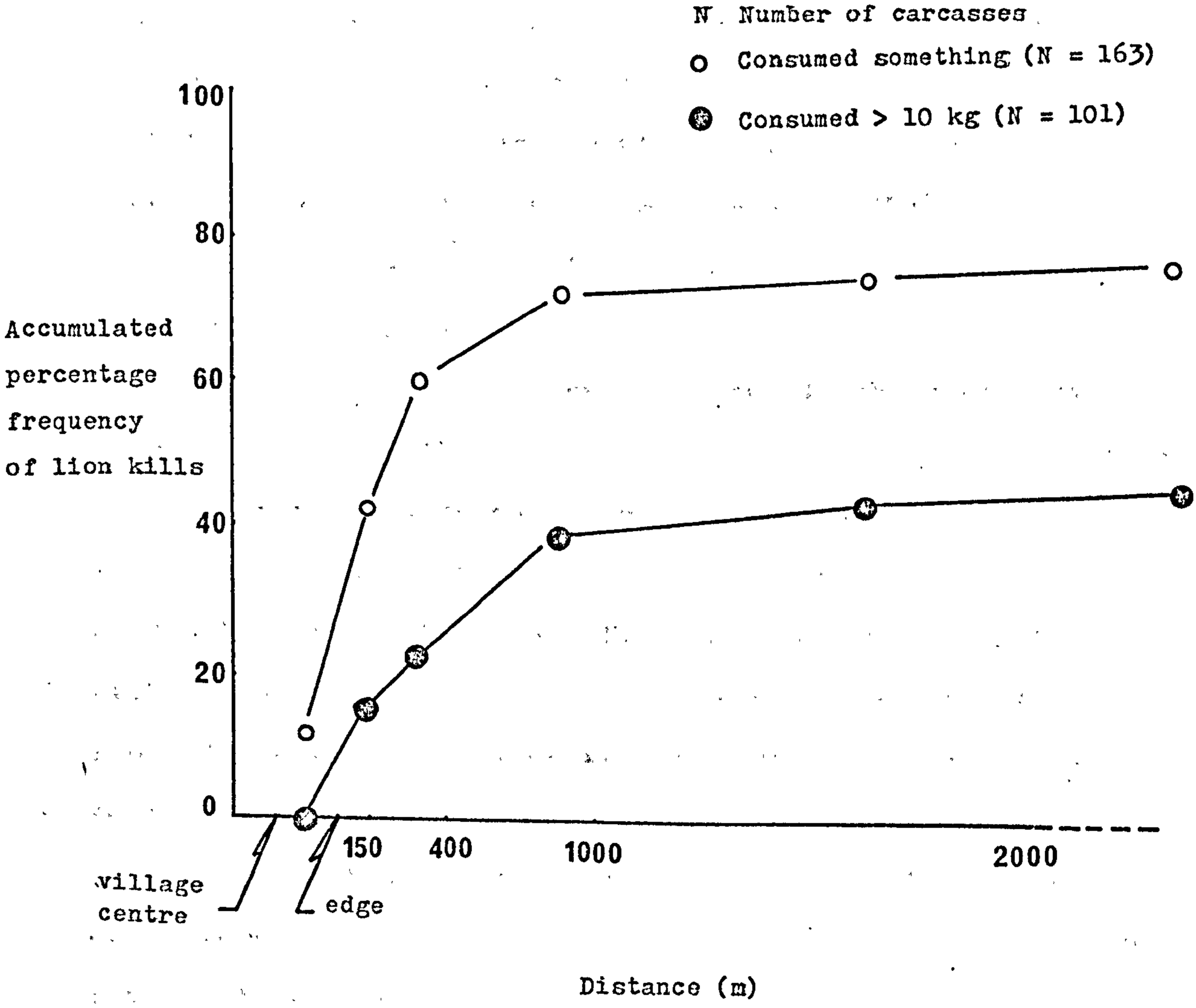
At night lions obtained most of their prey from villages. Few animals killed inside villages were eaten, while most animals killed outside villages were fed upon (fig.40). The pattern was similar for carcasses from which lions ate more than 10 kg. Feeding was completely prevented in villages unless the prey was dragged outside the fences before the lions were driven off. Lions were able to feed better by day when stock was out grazing, but still lost substantial amounts.

Hide collectors: Lions failed to eat much of what they killed in the day time, because they were driven off by the graziers and because other people scavenged the meat. Herdsmen reported that they attempted to drive lions away in 72% of 169 lion attacks. Once driven off,

Table 7: Amounts consumed by lions from each kill.

| Amount removed from carcass | Number of animals | Percent | Adjusted percent |
|---|---|---|---|
| Nothing | 42 | 24 | 24 |
| 1-5 kg | 13 | 8 | 11 |
| 6-10 kg | 13 | 8 | 11 |
| A large portion (approx. half) | 33 | 19 | 26 |
| Fully utilised | 35 | 20 | 28 |
| Some | 37 | 21 | -- |
| Total | 173 | 100 | 100 |

Fig. 40: The effect of increasing distance from village centre on average amount of killed prey eaten by lions



lions sometimes did not return or did so after a period of absence. In the meantime the herdsmen informed hide collectors who paid them for the meat and hide. If lions were present when hide collectors arrived, they drove the lions off. Hide collectors claimed 56% of 210 kills examined (fig.41). They did not bother so much with calves as with adults ($N = 168$; $x^2 = 3.07$; $d.f. = 1$; $0.1 > p > 0.05$). The largest hides also represented the greatest amounts of potential lion food. Whenever hide collectors claimed lion kills outside villages, lions fed from fewer livestock and ate lesser amounts (fig.43). Lions were more successful in feeding from afternoon kills because hide collectors were sometimes informed too late to claim the carcasses before dark.

Lions utilised 25% more kills inside the sanctuary than outside ($N = 177$; $x^2 = 7.82$; $d.f. = 1$; $p < 0.01$), probably because hide collectors claimed about 25% fewer kills inside than outside ($N = 210$; $X^2 = 7.36$; $d.f. = 1$; $p < 0.01$). They lived in only 5% of the 135 villages within the sanctuary, but in all 36 villages surveyed among 70 possible villages within 2 km of the sanctuary edge. More carcasses were claimed inside than would be expected from the distribution of hide collectors because collectors came into the sanctuary from outside, mainly to claim cattle from their villages.

Hide collectors did not take the meat, if the distance to carry it was too great, or they already had meat at home. However when meat was left it was usually taken by

vultures, predominantly white backed vultures (Gyps benghalensis), and only rarely by lions. Hide collectors attracted vultures by pulling carcasses into the open. Skinned carcasses were easily eaten by vultures. It took only 13-30 min to consume three adult bovids (fig.42). In contrast less than 3 kg was consumed by vultures from two intact adult bovids after 30 min of intense activity. Vultures were able to penetrate the hide only at the anus, mouth, nostrils, eyes and ears. Even after the abdominal cavity of a third carcass had been penetrated, vultures consumed less than 20 kg in 3 hours. Mr Robert Grubh (pers. com.) has subsequently made many similar comparisons.

Dragging carcasses: I could tell whether lions had moved carcasses in 120 cases. In 53% they were moved and frequently they were dragged into ravines, under cover or away from sources of disturbance like villages, to be concealed from scavengers or competitiors. The carcasses were moved on average about 150 m and varied from 10-1000 m. Lions improved their feeding success when carcasses were moved. They fed on 96% of 53 carcasses which they moved and on only 50% of 52 carcasses which they did not ($N = 105$; $X^2 = 26.37$; $d.f. = 1$; $p < 0.001$).

Compensation: Payments were made by the Gujarat government to herdsmen whose bovid stock had been killed by lions. Its purpose was to discourage the herdsmen from poisoning lions in retaliation, and so maintain the system of lions preying on domestic stock with the minimum of hardship to the herdsmen. The number of reported cases

Fig.41: Women removing the hide from a buffalo killed by lions

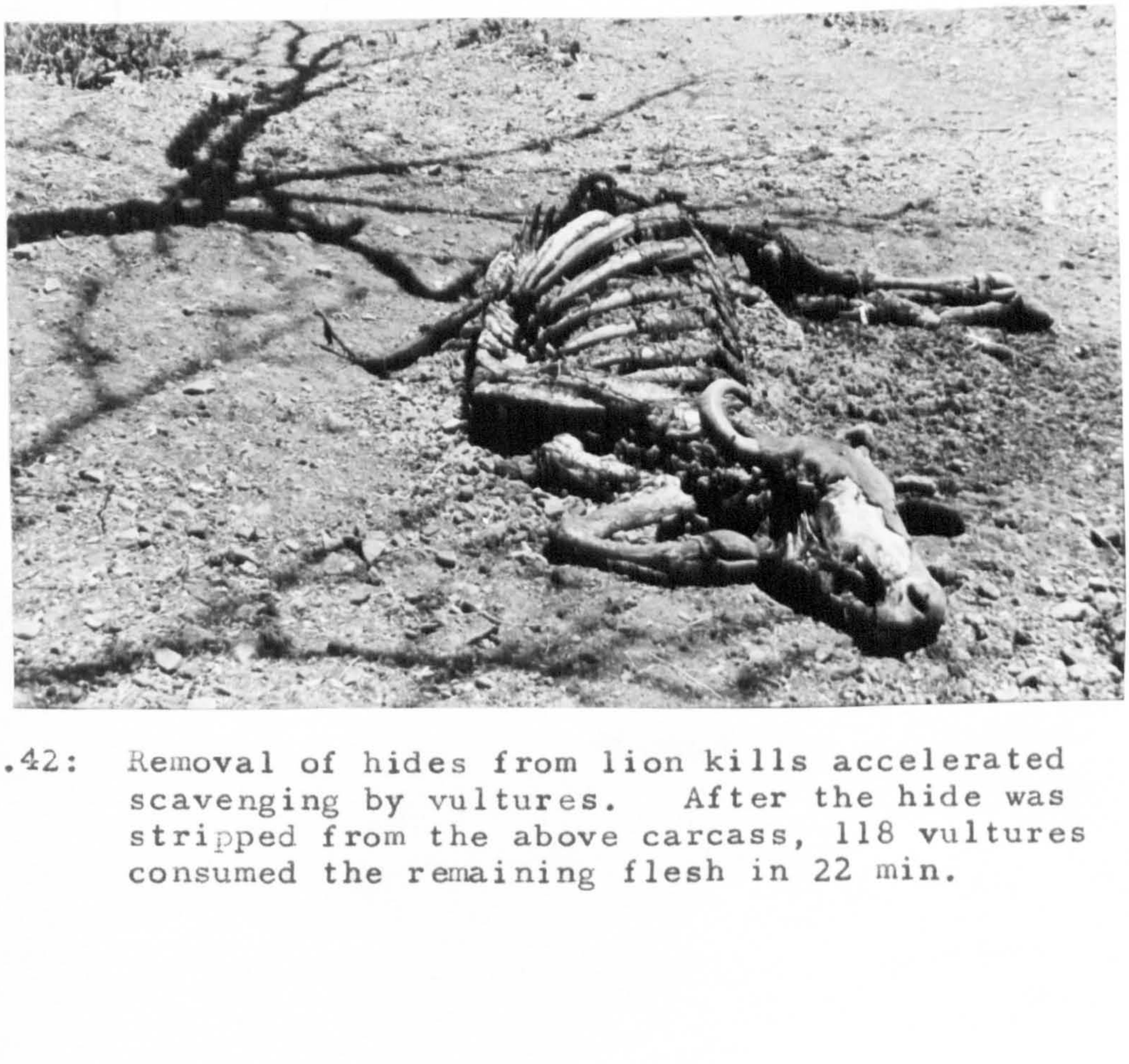
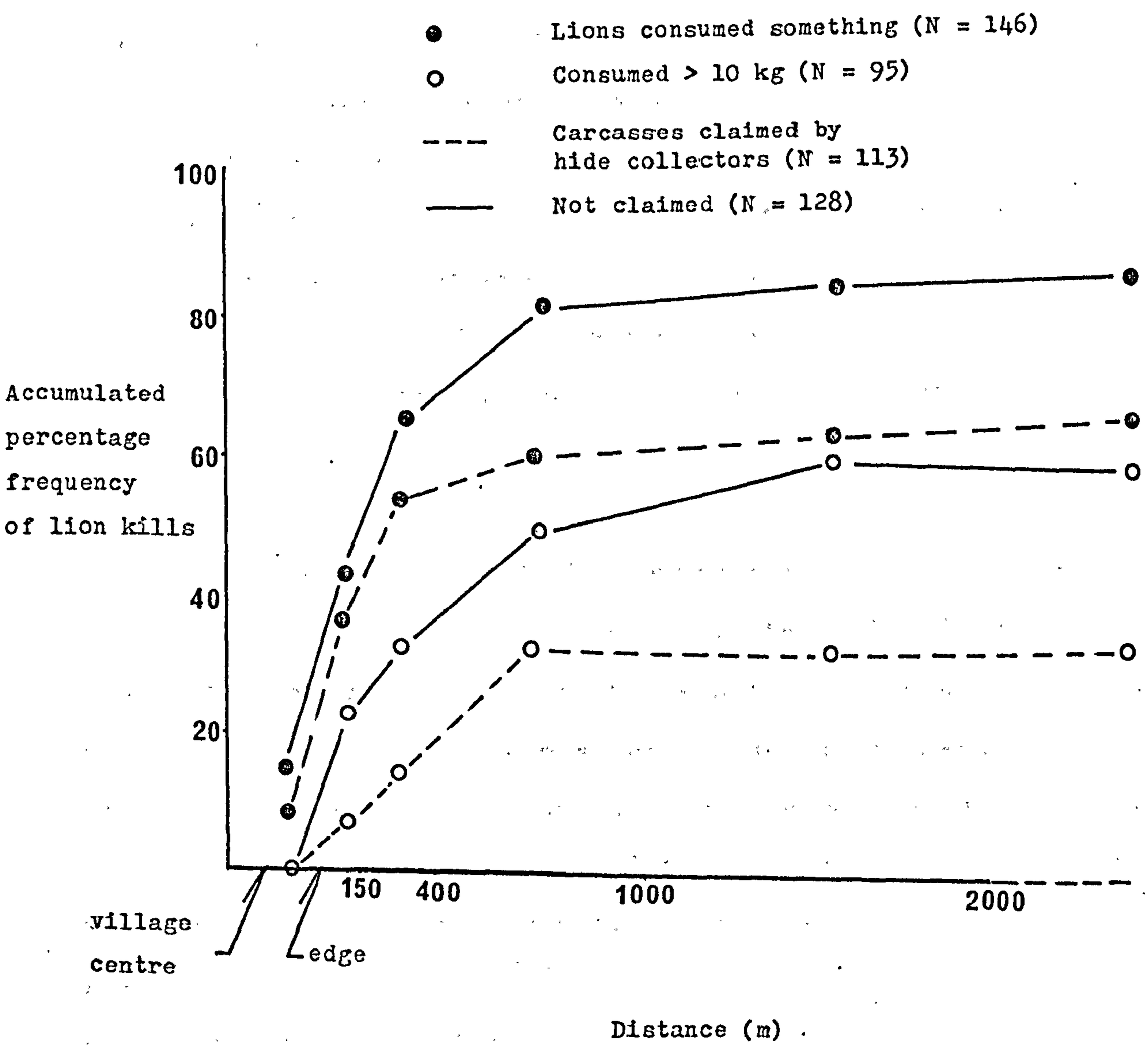


Fig.42: Removal of hides from lion kills accelerated scavenging by vultures. After the hide was stripped from the above carcass, 118 vultures consumed the remaining flesh in 22 min.

Fig. 43: Effect of appropriating lion kills by hide collectors on the average amounts eaten by lions from each carcass in relation to the distance at which prey were killed from village centre



of poisoning averaged about one per year; presumably of minor importance to the lion population as a whole. Whether such a low level was attributable to compensation payments was questionable. When I asked herdsmen who lost stock whether they intended to request assistance, only 49% replied in the affirmative. In many cases the herdsmen only had to walk 100 m from my office to the government office in order to make notification. They could have been paid compensation of Rs 100-250 for each animal, while I only offered Rs 10 for the opportunity of seeing their loss, independent of the number at one time. Probably fewer than 49% of the people whom I did not interview applied for compensation, because my sample consisted of herdsmen who had shown initiative in the first place.

Many complained about the compensation system. Few understood the conditions for eligibility, all had to wait months for payment, and when it was not forthcoming they were rarely told why. The sanctuary superintendent kindly made available the application records between April 1969 and January 1971. In that time 430 applications were received, and 25% rejected. Compensation was not given to those:

a) whose stock was killed more than two furlongs (c 400 m) from their village;

b) who possessed more than 20 head of stock;

c) who lived outside the sanctuary, but grazed their stock

stock more than two furlongs (c.400 m) inside the sanctuary;

d) who lost camels, goats, horses and other non-bovids.

Sixty-two percent of 252 lion kills which I examined were further than two furlongs from the village of origin. Ignorant of the importance of distance, 45% of herdsmen who lost stock beyond two furlongs said they were intend-:ing to apply for compensation. Similarly in 35% of 150 cases herdsmen possessed more than 20 animals. None knew that they were not eligible for compensation. These results show that the compensation system was of little practical benefit to herdsmen.

## CONCLUSION

My main aim was to assess the factors affecting the use of domestic stock as prey, and how efficiently lions were able to utilise what they killed. The methods used also provided information about prey selection, the manner in which prey was killed, and the response of herdsmen to the compensation scheme.

1. Although lions were most active at night, only 39% of domestic stock was attacked then, because stock was either corralled or removed from the sanctuary at night. By day, attacks mostly occurred about mid morning and in mid afternoon. These peaks were a compromise between lion activity, which was lowest through the middle of the day, and the abundance of grazing prey, which built up in the morning, then decreased in the afternoon.

2. Lions ate none of 24% of their kills, and utilised limited amounts of the others. Feeding was poorest at night when lions ate nothing from 41% of kills, largely because lions were unable to remove their kills from villages. In day time, lions were usually able to eat something, but also lost substantial amounts, mainly due to hide collectors who scavenged what the lions caught. If hide collectors did not take the meat, they made it so accessible to vultures as to make further use by lions impossible. Fifty-six percent of kills investigated were ultimately claimed by hide collectors, most of whom had come from outside the sanctuary.
3. Of 330 attacked animals examined from the sanctuary and surrounding lands, 40% were cows, 41% buffalo, 13% oxen and 6% consisted of the combined totals of camel, sheep, goat, horse and dog. Lions showed a strong preference for cows over buffalo, and this may be why 75% of stock kept by herdsmen within the sanctuary were buffalo. Lions also killed proportionately more young buffalo than young cows. The preference for cows of all ages was probably because adult buffalo were often aggressive towards lions, while adult cows were not; and because grazing buffalo were more favourably placed within the herd to receive protection from herdsmen.
4. There was a poor response to the compensation scheme. Among those surveyed, less than half applied for

compensation, while there were many reasons to suspect that the proportion was much smaller among those whom I did not interview. The herdsmen were discouraged because they either waited several months for payment or received none at all. Many were unaware that they were not eligible.

# CHAPTER 8

# POPULATION STRUCTURE

## INTRODUCTION AND METHODS

The structure of two prides was studied in detail, and that of others, superficially. Attempts were made to define home ranges, areas of concentrated use, population densities, social structures and patterns of movement. These were based on lion sightings made daily throughout the dry seasons between 1968-71. Additional information on the group structure of lions when attacking domestic stock was obtained during an investigation of herdsmen's losses (see p. 70 ).

The sightings included my own and those of game keepers. Each morning 10-12 game keepers searched for lions within a 20 km radius of the station headquarters, and reported the locations of those found to their superiors, who then arranged for tourists to be taken to the locations. Of necessity the game keepers' reports were accurate, and I generally used them for locating lions for my own observations. A few of the most easily identifiable lions had been given names, and these were reported by the game keepers as well. I recognised these and other lions by permanent scars, such as torn ears and some persistent scratches, in conjunction with sex, approximate age and shape (fig.44). The most reliable identification was the pattern of spots at the base of the whiskers which remained unchanged throughout life, and differed slightly for each individual (Pennycuick and Rudnai, 1970), but, because this technique required extremely close observation, it was rarely used.

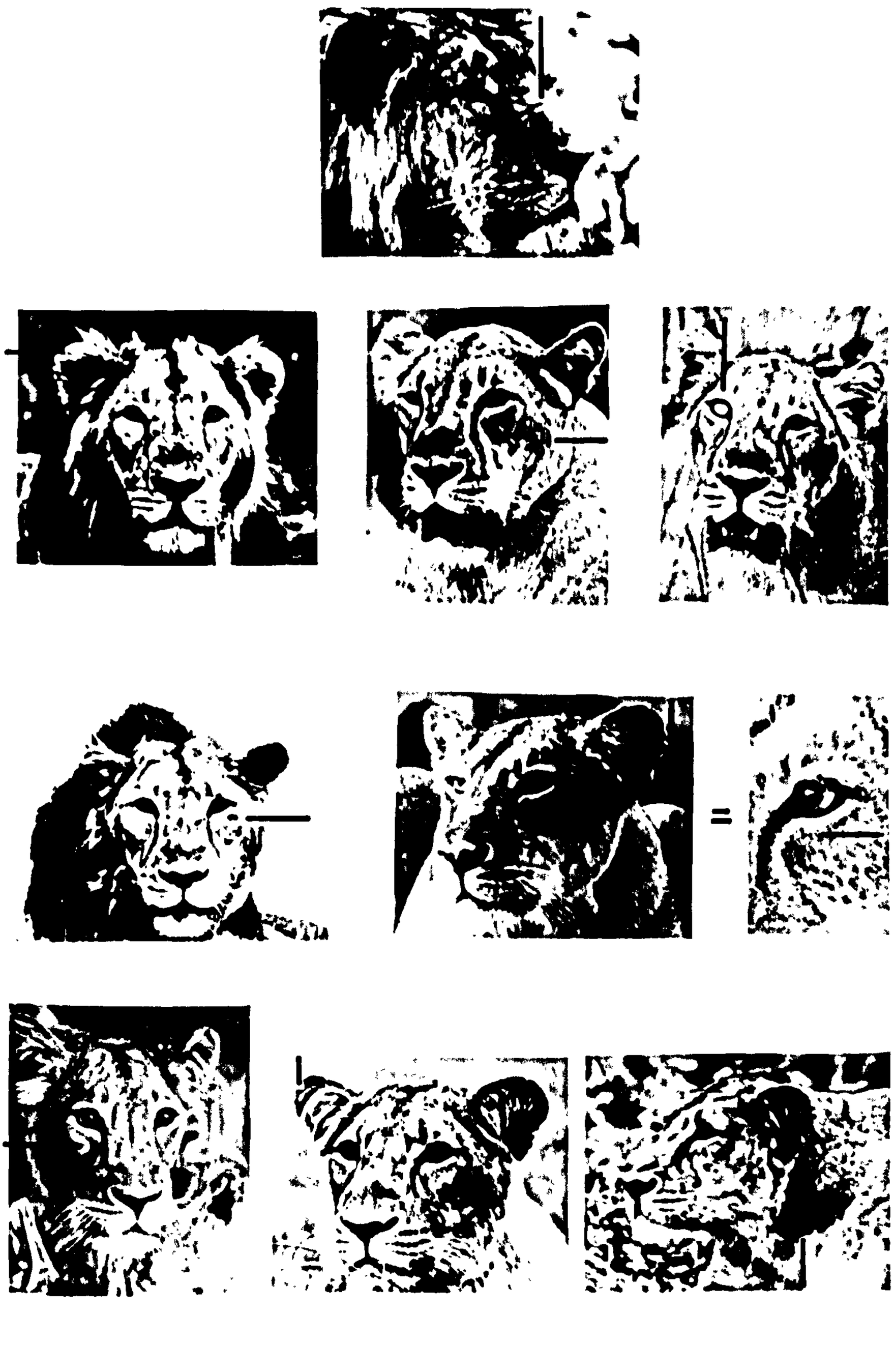


Fig.44: Injuries used in the identification of lions

RESULTS

Group structure at rest: Group size per sighting varied from 1-20 lions, with a mean of 3.3 $\pm$ 0.3 for 319 observations, the numbers mainly varying with the sex. In 191 observations of males, group size was 1-4 with a mean of 1.6 $\pm$ 0.1, while in 210 observations of females, group size varied between 1-11 with a mean of 2.1 $\pm$ 0.2 females (Table 8). Data collected by game keepers in 1961-62 and 1968-71, and kindly made available to me for analysis, did not differ significantly from mine (Table 9).

Schaller (1972) defined a 'pride' as the sum total of all the lions in an area which interacted peaceably. He found that among Serengeti lions a pride was not a cohesive social unit in the sense that all members were not together at the same time. Instead a pride represented a loose arrangement, where only some members commonly associated with others. His definition applies equally to the Gir situation where I rarely saw all the members of a pride together at the same time.

For one pride, I recorded the number of times each of five lions was seen with each of the others. A single association was defined as one lion seen in the vicinity of another in one day, regardless of whether they spent a little or most of the day together. A lion seen in the company of two others in the same day was classified as having associated once with each, whether the two associations occurred simultaneously or separately. One male

Table 8: Number of lions of each sex recorded in sightings made by the author in 1968-71

| Number of males | Absolute frequency | Relative frequency | Number of females | Absolute frequency | Relative frequency |
|---|---|---|---|---|---|
| 1 | 91 | 47.6 | 1 | 109 | 51.9 |
| 2 | 87 | 45.5 | 2 | 38 | 18.1 |
| 3 | 9 | 4.7 | 3 | 41 | 19.5 |
| 4 | 4 | 2.1 | 4 | 5 | 2.4 |
| 5 | - | - | 5 | 4 | 1.9 |
| 6 | - | - | 6 | 6 | 2.9 |
| 7 | - | - | 7 | 2 | 1.0 |
| 8 | - | - | 8 | 1 | 0.5 |
| 9 | - | - | 9 | 3 | 1.4 |
| 10 | - | - | 10 | - | - |
| 11 | - | - | 11 | 1 | 0.5 |
| Total | 191 | 100 | Total | 210 | 100 |
| Mean | | 1.6 | Mean | | 2.1 |
| Standard error | | 0.05 | Standard error | | 0.1 |
| Standard deviation | | 0.6 | Standard deviation | | 1.7 |

N.B. Data includes sightings of both mixed and unmixed sexes.

Table 9: Number of lions of each sex observed in sightings by game keepers in 1961-62 and 1968-71

| | Minimum | Maximum | Mean | Number of sightings |
|---|---|---|---|---|
| 1961-62* | | | | |
| Number of males | 1 | 2 | 1.0 | 58 |
| Number of females | 1 | 8 | 2.6 | 105 |
| 1968-71 | | | | |
| Number of males | 1 | 4 | 1.6 | 424 |
| Number of females | 1 | 12 | 2.0 | 826 |

* Data obtained from the daily record of lion sightings recorded in the sanctuary superintendent's diary.

and three females could associate with each male, while two males and two females could associate with each female. These are the expected ratios, if lions associated with others at random, but the observed ratios were distinctly different. They indicate that lions associate preferent-:ially with their own sex (Table 10). Similarly when data was analysed from 1382 sightings involving any lions in any pride, adult lions were seen with adult members of the same sex approximately three times as often as with members of the opposite sex.

The results were anticipated. Pairs of males were commonly seen together, either while resting, travelling or feeding. They usually roared together, sprayed or scraped in turn at the same sites, and sometimes were sufficiently friendly to feed simultaneously with heads touching. In contrast, only when courting was there much evidence of a strong bond between males and females. At other times, male lions often intimidated females, particularly at the time of arrival of either. In one instance a lioness with two cubs approximately 5 months old, upon hearing the mere roaring of a pride male in the vicinity, left a carcass and trotted in the opposite direction, travelling at least 300 m before we lost her.

Bonds between females were also stronger than those between males and females. Females commonly rubbed heads whereas head rubbing between the sexes was only observed during courting. Females often shared a large carcass,

Table 10: The actual and calculated expectations of finding male and female lions of the test pride in the company of each other

| Lion | Male with male | Male with female | Female with female | Total | Chi square | Significance |
|---|---|---|---|---|---|---|
| Male A | | | | | | |
| Observed frequency | 165 | 141 | N.A. | 306 | > 7.88 | < 0.005 |
| Expected frequency[1] | 76.5 | 229.5 | N.A. | | | |
| Male B | | | | | | |
| Observed frequency | 165 | 148 | N.A. | 313 | > 7.88 | < 0.005 |
| Expected frequency[1] | 78.2 | 234.8 | N.A. | | | |
| Female A | | | | | | |
| Observed frequency | N.A. | 103 | 320 | 423 | > 7.88 | < 0.005 |
| Expected frequency[2] | N.A. | 211.5 | 211.5 | | | |
| Female B | | | | | | |
| Observed frequency | N.A. | 93 | 265 | 358 | > 7.88 | < 0.005 |
| Expected frequency[2] | N.A. | 179.0 | 179.0 | | | |
| Female C | | | | | | |
| Observed frequency | N.A. | 93 | 311 | 404 | > 7.88 | < 0.005 |
| Expected frequency[2] | N.A. | 202.0 | 202.0 | | | |

[1] Available male to female ratio 1:3

[2] Available male to female ratio 1:1

N.A. = not applicable

whereas males and females were only once observed together at the same carcass. Similarly females often travelled together, but rarely with males.

Group structure when attacking livestock: Eighty-four percent of 234 attacks upon herdsmen's stock involved three lions or less, with a mean of 2.4; the mean number of livestock either killed or injured per attack was 1.5. The larger the number of lions involved, the greater the number of bovids caught per attack. However, the number of animals attacked per lion tended to decrease as the number of lions involved increased (Table 11), probably because the larger the lion group size the greater was the proportion of inexperienced cubs (Table 12), although cooperative selection of the same prey by adults may also have been involved.

The number of lions seen by farmers in attacks was consistently less than the number seen by game keepers and me (fig.45). Herdsmen sighted single lions 22% more frequently than the game keepers and I ($N = 1615$; $X^2 = 71$; $d.f. = 1$; $p < 0.001$).

Movements: The distances travelled by males and females were estimated using data from three males and three females recorded in the dry season (November to May inclusive) for two years. The extent of movement was recorded as the distance travelled in a straight line between two sightings. Although this was less than the true distance travelled, it did not invalidate the comparison

Table 11: Mean number of animals caught per attack and per lion in relation to increasing lion group size

| No. of lions per attack | Total number of attacks | Total number of animals killed or injured | Mean number of animals caught per attack | Mean number of animals caught per lion |
|---|---|---|---|---|
| 1 | 84 | 91 | 1.1 | 1.1 |
| 2 | 65 | 85 | 1.3 | 0.7 |
| 3 | 48 | 75 | 1.6 | 0.5 |
| 4 | 15 | 29 | 1.9 | 0.5 |
| 5 | 8 | 16 | 2.0 | 0.4 |
| 6 | 8 | 19 | 2.4 | 0.4 |
| 7 - 13 | 6 | 24 | 4.0 | 0.5 |
| Total | 234 | 339 | | |

Table 12: Number of lions and number of cubs seen by herdsmen during or following an attack upon their livestock

| Number of lions per attack | Total number of lions observed | Total number of cubs observed * | Mean number of cubs per attack |
|---|---|---|---|
| 1 | 84 | 0 | 0 |
| 2 | 130 | 5 | 0.1 |
| 3 | 144 | 29 | 0.6 |
| 4 | 60 | 28 | 1.9 |
| Total | 418 | 62 | |

* Cub numbers observed were a minimum because herdsmen often did not differentiate between adults and cubs.

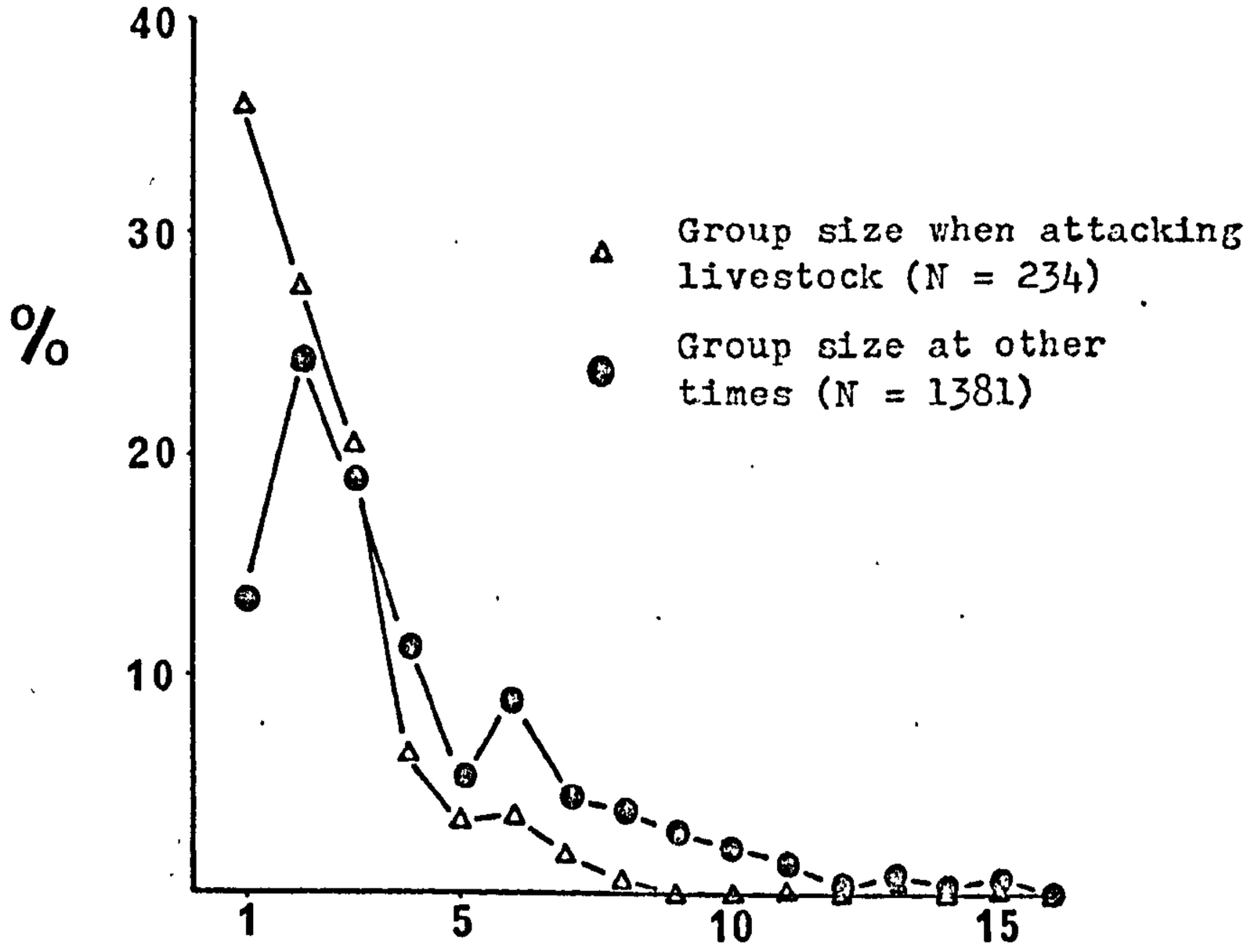



Fig. 45: Numbers of lions sighted both when reported by herdsmen following attacks upon their livestock, and when observed by game keepers and myself at other times

between sexes.

More observations were obtained in 1970 than in 1969. Females were seen nearly twice as often as males. Some individuals were seen more frequently than were others. So as to remove bias created by these differences, I selected an equal number of sightings for each lion in each year with the aid of a table of random numbers. Fifty-two sightings were recorded for each lion per year, or an average of one every fourth day in the dry seasons.

Table 13 and figure 46 show the results which were obtained. The distribution of distances travelled between sightings were positively skewed, with the minimum and mode equal to zero and the median located to the left of the mean. The results were consistant, whether the comparison was made between years, between sexes, or between individuals. Excluding those observations when no movement was detected, the following was ascertained: on average females moved 2.5 km, and 95% of their movements were within less than 5.3 km; males averaged 5.3 km, and 95% of their movement did not exceed 13.4 km.

These differences were not unexpected. Females had cubs to support most of the time, which restricted the amount of movement that was possible. In contrast, males had no dependents, but had the almost exclusive role of advertising their presence. If the function of adver-:tisement is to establish a presence and so maintain a territory, then the area occupied must also be frequently

Table 13: Central tendency statistics of distance travelled by lions between sightings averaging four days apart.

| Lions | No. of obs. | Mean (km) | Minimum = mode (km) | Median (km) | Maximum (km) |
|---|---|---|---|---|---|
| 3 females 1969 | 150 | 1.0 | 0 | 0.2 | 13 |
| 3 females 1970 | 150 | 1.2 | 0 | 0.7 | 7 |
| 3 males 1969 | 150 | 3.9 | 0 | 1.6 | 23 |
| 3 males 1970 | 150 | 3.2 | 0 | 1.4 | 17 |
| Female A | 100 | 1.6 | 0 | 0.4 | 13 |
| Female B | 100 | 0.9 | 0 | 0.3 | 10 |
| Female C | 100 | 0.7 | 0 | 0.4 | 4 |
| Male A | 100 | 4.1 | 0 | 2.8 | 21 |
| Male B | 100 | 3.8 | 0 | 1.4 | 23 |
| Male C | 100 | 2.8 | 0 | 1.1 | 17 |

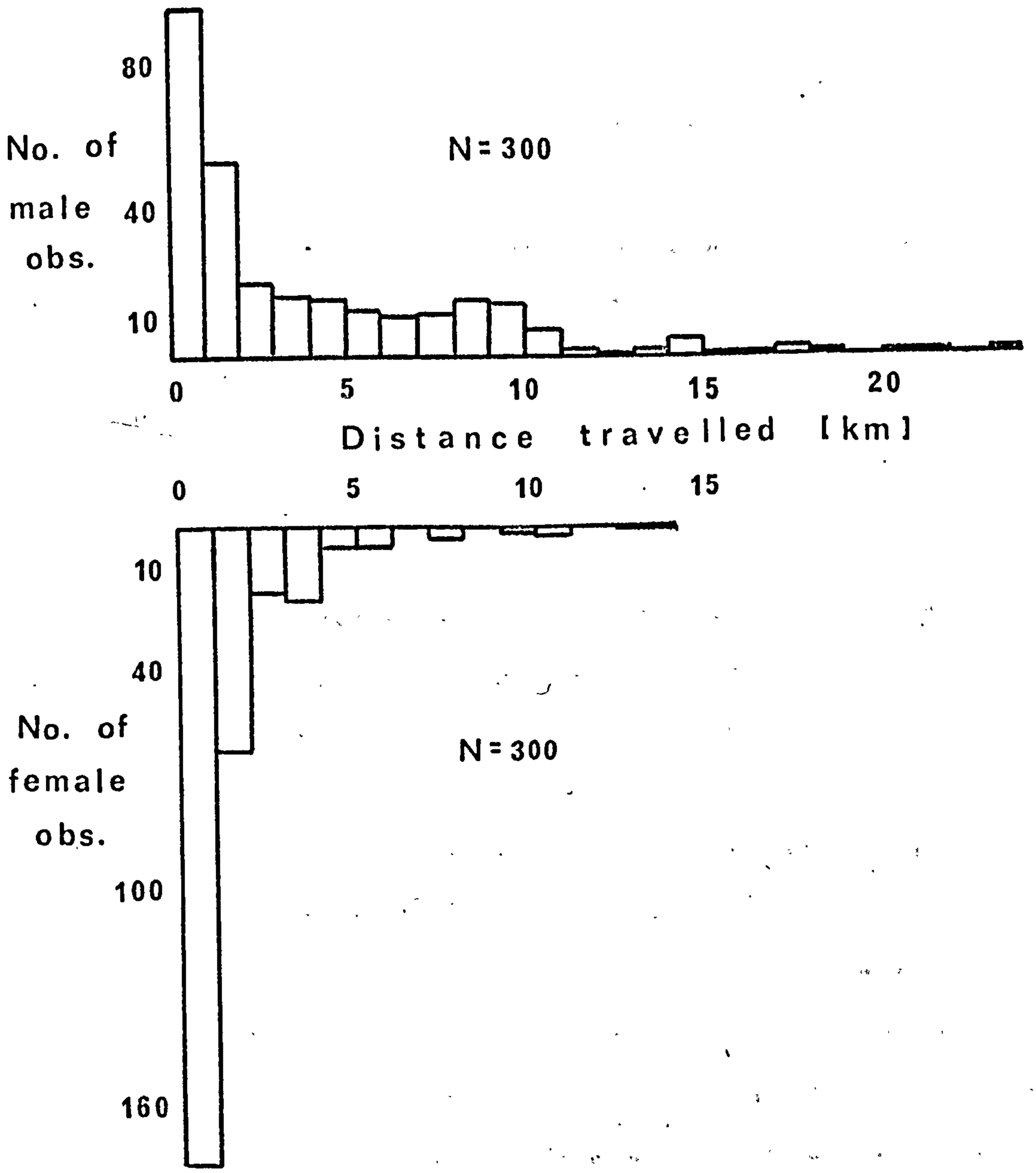



Fig. 46: Distance travelled between sightings averaging four days apart by each of three male and three female lions

traversed, which is what male lions did.

Both males and females moved less than they would have, had they not had their diets supplemented with government offerings of buffalo calves. Because females had their diets supplemented more often than males, this exaggerated the differences in the amount of movement by the two sexes. However, it was only because females were more sedentary that it was possible to supplement their diet more frequently.

Home ranges: I plotted the approximate home ranges of two lion prides by drawing polygons encompassing all of the sightings made by game keepers and myself during a three year period (fig.47 and 48). Because most sightings were of lions at rest, the areas of the observed ranges may have been less than that which lions actually traversed, as for example when hunting. The home ranges for females and males were c 70-80 $km^2$ and 75-190 $km^2$ respectively (Table 14). The average density for the two prides was one lion per 6.3 $km^2$. The density of adult males was one per 37-94 $km^2$, and that of lionesses and dependent cubs was one per 4.8-6.2 $km^2$.

Most sightings were concentrated within 3-10 areas of each home range (fig.47 and 48). Collectively, c 90% of sightings were recorded in c 20% of the area of these ranges. A similar usage of pride areas was observed by Schaller (1972) in the Serengeti lion. Ewer (1968) defined areas of concentrated use as 'core areas'. The home ranges

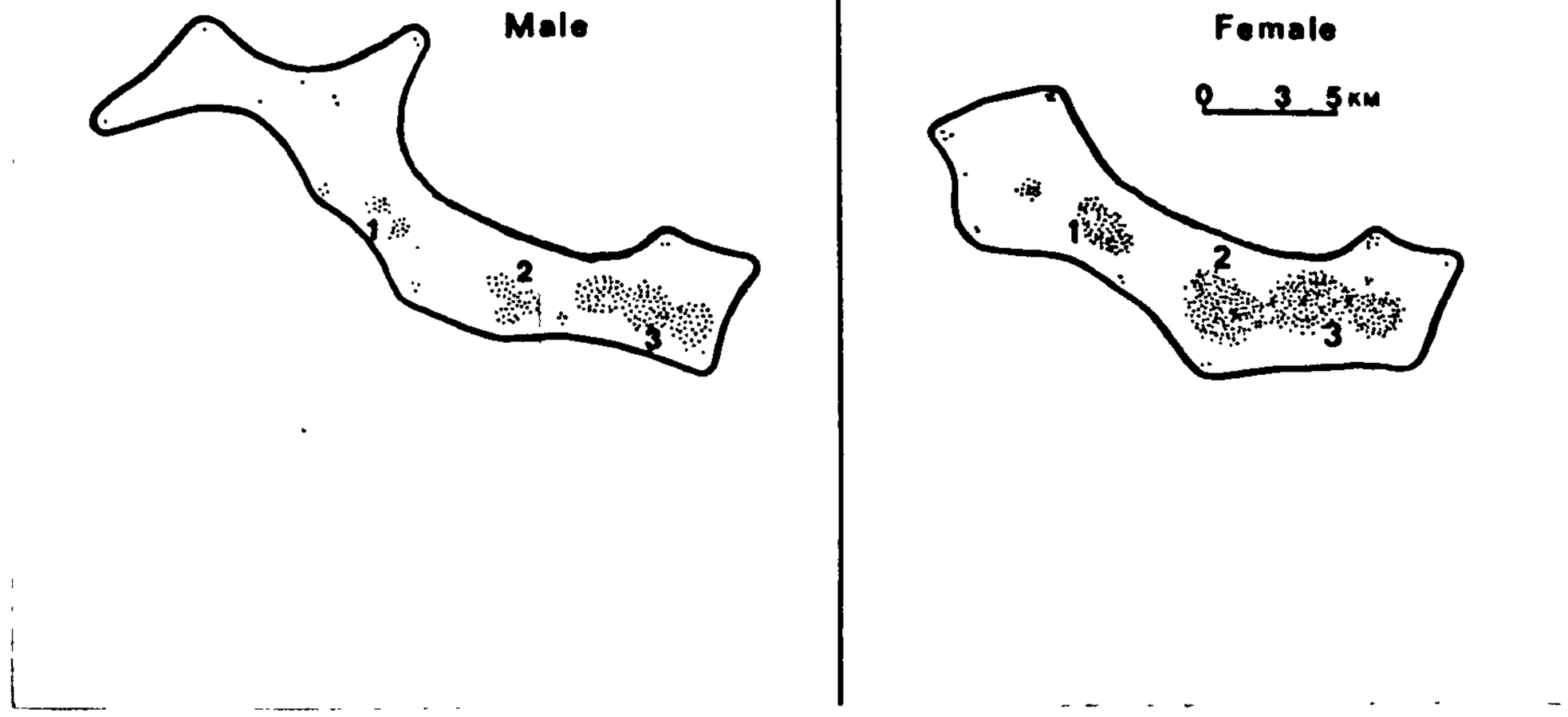



Fig.47: Home range polygons for adult male and female lions in pride 'A' in 1968-71.

Each dot represents a single sighting of one or more lions. The line encircling the outermost sightings marks the assumed boundary of the home range. Sightings were often concentrated in specific areas, and where numbered were identical for both sexes. The groups of sightings accurately reflect numbers of sightings, and are not meant to indicate the size of each location.


Fig.48: Home range polygons for adult male and female lions in pride 'B' in 1968-71.

Table 14: Lion densities for two prides assessed from home range polygons

| | Area of polygon (km) | Number of lions | Mean number of lions per $km^2$ |
|---|---|---|---|
| Pride A | | | |
| Males | 74.3 | 2 | 37.2 |
| Females and cubs | 72.0 | 15* | 4.8 |
| Pride B | | | |
| Males | 188.3 | 2 | 94.0 |
| Females and cubs | 81.1 | 13* | 6.2 |
| Total utilized by either pride | 201.9 | 32 | 6.3 |

* Cub portion averaged for the three years.

and core areas were largely coincident for males and females within each pride, although the two sexes were not usually seen together, even in the most frequented areas. Lions of one sex were seen in the company of the opposite sex in only 32% of 1124 sightings of lions recorded in core areas.

Although the ranges of females in prides 'A' and 'B' overlapped a little on rare occasions, the ranges of males in prides 'A' and 'B' overlapped substantially, and much more frequently (fig.49). Males from other prides also made extensive forays into the ranges used by males in prides 'A' and 'B'.

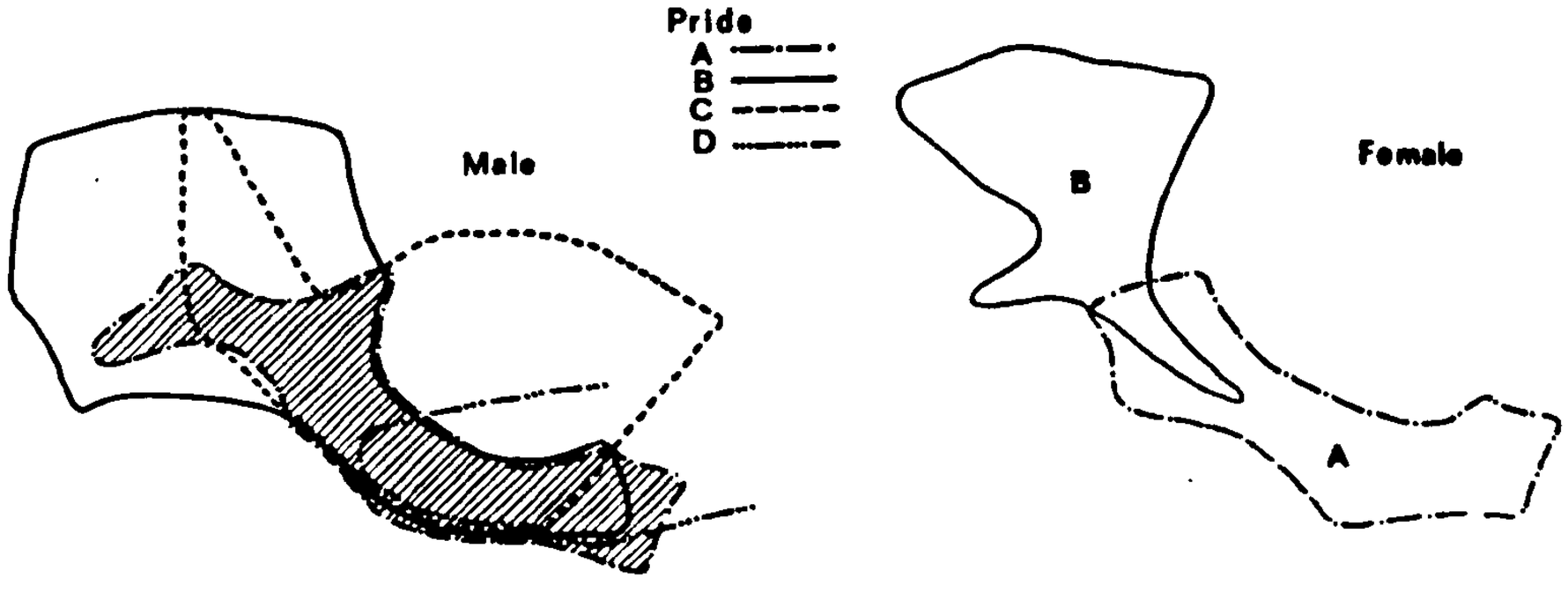



Fig.49: Extent of overlap of ranges between male lions in four prides and females in two prides.

## DISCUSSION AND CONCLUSION

Each of the two prides studied consisted of two males and several females with cubs. Rarely were all pride members seen together; and outside courting, lions associated mainly with members of their own sex, and with cubs in the case of adult females. Herdsmen commonly reported seeing single lions when their stock was attacked, suggesting that lions often hunted alone.

According to Davis et al (1963), a home range is that area utilised by an animal in its normal activities. This need not mean that a home range is a continuous area enclosed within defined boundaries (Ewer, 1968). When cover reduces visibility it is not uncommon for a home range to be restricted to a number of places of special importance, such as feeding, watering, sleeping, etc., connected by a series of pathways. Animals which are both intolerant of each other, and inhabit large ranges, can overlap extensively while still maintaining a rigid system of spacing based on time rather than area. For example, Leyhausen and Wolff (1959) found among free ranging domestic cats that it was common for neighbours to use the same pathways, while avoiding each other by travelling at different intervals. A cat using a pathway would examine it for the presence or absence of fresh sign by the previous user, and adjust the rate of travel so as not to overtake.

A similar system probably operates among lions. They

restricted their movements predominantly to pathways, most commonly roads. Lions with overlapping ranges travelled the same pathways. Male lions were responsible for almost all cases of overlapping ranges, and it was they that used a variety of methods to mark their routes, in addition to frequent roaring while travelling. Movement was not hurried. Few fights were recorded between neighbouring males, even though in the best studied pride neighbouring males were known to have entered the home range of the resident males 129 times.

Males moved more frequently and travelled greater distances than females. Both sexes commonly rested in the same few parts of the range, though not usually at the same time.

# CHAPTER 9

# POPULATION SIZE

INTRODUCTION

I determined the approximate number of lions using four methods, and compared the results with those obtained by other investigators. Three of the methods used, namely road counts, counts at waterholes and density assessment of known prides are described on pp. 30 , and 115 . The fourth was based on amounts of domestic bovids consumed per year, and the amount of food required per lion per year. The estimates were complex, utilising data from a variety of sources.

RESULTS

Road counts: Fourteen lions were seen at night during the 1969 road count, which sampled approximately 77 $km^2$ of the 1265 $km^2$ sanctuary (see p. 32 ). If the density of lions seen in the sample area was the same for the rest of the sanctuary, then the sanctuary had c 230 lions.

Counts at waterholes: Seven lions and 218 wild ungulates were seen at waterholes in 1969 (see p. 34 ). If the ratio of lions to wild ungulates at waterholes was the same as in the rest of the sanctuary, and if the estimate was correct of 5600 wild ungulates in the sanctuary as calculated from the 1969 road count, then there were c 180 lions in the sanctuary.

Density of known prides: In 1968-71, 32 lions belonging to two prides were observed in an area of approximately 202 $km^2$, or 6.3 $km^2$/lion (see p. 115 ).

Assuming the density was the same for all lions in the sanctuary, then by extrapolation there were c 200 lions in the sanctuary.

Lion numbers based on prey utilisation: The follow-:ing formula was used to assess lion numbers,

(1) $$\text{Numbers of lions} = \frac{KW}{FB}$$

where K = total bovid population killed per year

W = average amount consumed from each bovid

F = average amount of food consumed per lion per year

B = proportion of consumed food consisting of domestic bovids

Each of the component parts of the formula were assessed as follows:

(2) $$K = \frac{RV}{S}$$

where R = number of bovids killed per village per year inside the sanctuary (see p.140)
= 15.1

V = number of villages inside the sanctuary
= 135 (Mary Ann Berwick, pers. com.)

S = proportion of bovid kills originating from villages within the sanctuary (see p.77)
= 60.7%

$$K = \frac{15.1 \times 135}{0.607} = 3360 \text{ bovids killed per year}$$

(3) $$W = P_1W_1 + P_2W_2 + P_3W_3 + P_4W_4$$

where $P_1$ = proportion of natural kills from which lions ate nothing

In a sample of 173 natural kills of domestic bovids, lions ate nothing from 24%, 1-10 kg from 22%, approximately half of the available flesh from 26% and all available flesh from 28%

= 24%

$P_2$ = proportion of kills from which lions ate 1-10 kg

= 22%

$P_3$ = proportion of kills from which lions ate all available flesh

= 28%

$P_4$ = proportion of kills from which lions ate approximately half of the available flesh

= 26%

$W_1$ = average amount eaten per carcass when lions ate nothing

= 0

$W_2$ = average amount eaten per carcass when lions ate 1-10 kg

= approximately 5 kg

$W_3$ = average amount eaten per carcass when lions ate all available flesh

I was unable to determine this directly from natural kills. However I did measure the maximum proportion which lions could eat from carcasses during controlled feeding experiments, and then by taking into account the average weights of each type of prey available (i.e. adult buffalo, young buffalo, adult cow, etc) and the proportions of each prey type in the sample of natural kills, I was able to calculate the maximum average amount which lions could have eaten per carcass when all available flesh was consumed. The formula used for the computation was:

$$W_3 = M\left(T_1A_1 + T_2A_2 + T_3A_3 + T_4A_4 + T_5A_5\right)$$

where M = maximum proportion eaten per carcass

This was assessed by weighing calves before and after they were eaten during controlled feeding experiments, when lions had eaten the maximum possible, i.e. only inedible portions remained, such as hooves, rumen contents and a few large bones. The parts consumed included, as well as flesh, all the vertebral column, most of the rib cage, all of the hide including that around the skull, most of the appendicular skeleton, the stomach lining and large intestine. The amount consumed from 10 buffalo calves eaten to the maximum was 66.6% of the total biomass.

$T_1$ = proportion of adult buffalo among lion kills

Among 239 natural kills, 24.3% were adult buffalo, 18.8% young buffalo, 5.0% adult oxen, 32.2% adult cows, 19.7% young cow-oxen.
= 24.3%

$T_2$ = proportion of young buffalo among lion kills
= 18.8%

$T_3$ = proportion of adult oxen among lion kills
= 5.0%

$T_4$ = proportion of adult cows among lion kills
= 32.2%

$T_5$ = proportion of young cow-oxen among lion kills
= 19.7%

$A_1$ = average weight of adult buffalo

A sample of bovids were weighed alive on a platform scale. In a sample of 37 adult buffalo, including one male, the average weight was 341 kg
= 341 kg

$A_2$ = average weight of young buffalo

I arbitrarily assumed young buffalo to weigh about half that of adult buffalo, or approximately 170 kg. The mean weight of a sample of 13 young buffalo was slightly higher (184 kg), but did not include the youngest in the farmer's herd which were not sent for grazing.
= 170 kg

$A_3$ = average weight of adult oxen

The average weight of a sample of six oxen was

= 290 kg

$A_4$ = average weight of adult cows

The average weight of a sample of two cows was

= 194 kg

$A_5$ = average weight of young cattle (cow and ox)

Arbitrarily assuming the average weight of young cattle to equal half that of the adult cattle, would equal

$$= \frac{194 + 290}{2 + 2} \text{ kg} = 120 \text{ kg}$$

then $W_3$ = 0.666 ((0.243 x 341 kg) + (0.188 x 170 kg)

+ (0.050 x 290 kg) + (0.322 x 194 kg) +

(0.197 x 120 kg))

= 144 kg per carcass

$W_4 = \frac{1}{2}W_3$ = 72 kg per carcass

then W = (0.24 x 0 kg) + (0.22 x 5 kg) + (0.28 x 144 kg)

+ (0.26 x 72 kg)

= 60 kg per carcass

(4) F, or the average amount of food consumed per lion per year, was assessed by extrapolation from the results of three controlled feeding trials. Lions were given unlimited food for a number of days. The prey was weighed beforehand and the remains weighed after feeding. The difference in weight was assumed to be the amount eaten. F was computed in the following manner:

$$F = \left(\frac{QY}{\frac{L_{min} + L_{max}}{2}}\right)_N \quad \text{or} \quad \left(\frac{QY}{L_{avg}}\right)^N$$

where Q = total amount consumed during feeding trials
= 2063 kg

Y = 365 days per year

N = number of nights in which feeding trials were conducted
= 35

$L_{min}$ = minimum average number of lions subsisting on supplied food per night

The lions in the vicinity of food were counted before feeding at night and again the following morning. It was assumed that only lions actually seen had fed. To confirm that this was true the lions were observed throughout the night in 16 of 35 nights in which feeding trials were conducted. The average number of lions in the vicinity of food per night was 6.7, consisting of lionesses, cubs and an occasional adult male. This was the minimum average number of lions to have subsisted on supplied food per night, if it is assumed that all lions which were not seen on some nights obtained food elsewhere.

$L_{max}$ = maximum average number of lions subsisting on supplied food per night

If it is assumed that no lion obtained food elsewhere during feeding trials, then the maximum average number of lions to subsist on supplied food per night per trial was equal to the maximum number of individual lions involved per trial. Three feeding trials were conducted. The first trial lasted 10 days and involved 11 lions, the second 17 days involving 11 lions and the third 8 days involving 4 lions. The number of lions involved averaged for the three trials was 9.4 per night.

$L_{avg}$ = average number of lions subsisting on supplied food per night

During the feeding trials farmers in neigh-:bouring villages reported the loss of six

cattle, at least one of which was eaten by two lions which had appeared in the feeding trials. A reasonable estimate of the average number of lions subsisting on supplied food per night is:

$$\frac{L_{min} + L_{max}}{2} = \frac{6.7 + 9.4}{2} = 8.05$$

then F = 2672 kg per lion per year

(5) B, or the proportion of consumed food consisting of domestic bovids was assessed from faecal analysis (see p.44). Approximately 77% of 480 lion faeces collected throughout the lion range contained domestic bovids.

To return to the original formula (1), now that each of its component parts has been assessed, the estimated number of lions in the sanctuary and surrounding areas is equal to $\frac{KW}{FB} = \frac{3360 \text{ bovids/year} \times 60 \text{ kg/bovid}}{2672 \text{ kg/lion/year} \times 0.77} = 98$

F, or the average amount of food consumed per lion per year, c 2670 kg, is much larger than that calculated from feeding rates in captivity. Crandall (1964) recorded an approximate feeding rate of 1600 kg per adult male per year, and 1280 kg per adult female per year for lions raised in zoos. York (pers. com.) fed an average of 800 kg per captive cub per year. Adjusting for the proportions of males, females and cubs in the Gir population, as determined from 1382 sightings, the average amount of food consumed, if zoo feeding rates applied, is 1110 kg per lion per year. By substituting this new value of F in formula (1), the estimated number of lions is 236.

Captive lions often receive vitamin supplements. They are also less active than free-living lions. Both these factors contribute to a lower feeding rate than in the wild. The new calculation of the number of lions in Gir, based on zoo rates of food intake, is likely to indicate the maximum possible, assuming the other parts of the calculation are reasonable.

A small correction has to be made to the above two estimates of lion numbers, because some lions were given food in addition to what they killed naturally. Data obtained from the Gujarat forest department on the number of male buffalo calves given for the period April 1965 - February 1968 inclusive, averaged a feeding rate of 189 calves per year. The average weight of 17 calves which I weighed before they were fed to lions was 117 kg. The average amount of food consumed per calf during feeding trials was $\underline{c}$ 60%, or about 70 kg. By extrapolation, the amount eaten per year was $\underline{c}$ 13230 kg. The number of lions which this could support was approximately 5, assuming the average food intake per lion per year was 2670 kg, as determined from feeding trials. The maximum number of lions which could be supported was approximately 12, if zoo feeding rates applied.

## DISCUSSION AND CONCLUSION

The mean number of lions in five estimates was $\underline{c}$ 190, ranging from 100 to 250 (Table 15 ). The estimates made

Table 15 : Numbers of lions estimated using five methods

| Method | Approximate numbers of lions |
|---|---|
| Road count | 230 |
| Counts at waterholes | 190 |
| Density of known prides | 200 |
| Prey utilisation, assuming food intake equal to that recorded in the field | 100 |
| Prey utilisation, assuming food intake equal to that recorded in captivity | 250 maximum |

from road counts, counts at waterholes and lion density were for the sanctuary only, thus excluding some lions. However this was countered in estimates from road counts and lion density because of biases favouring over estimates. Lions used roads as pathways so that more lions were likely to be seen along roads than in the rest of the sanctuary. Known prides were given food in addition to what they caught naturally, and this may have resulted in a higher density of lions in known prides than in others.

Many assumptions were made in estimating the number of lions from their use of prey. For example, the average weights of adult buffalo, adult cows, etc., assessed from relatively small samples, were assumed to be representative of the weights of each type of bovid in the sanctuary; the ratios of males, females and cubs observed in the feeding trials were assumed to equal the ratio for the sanctuary as a whole; the proportion of domestic stock in the lion's diet was assumed to equal the percent occurrence of domestic stock recorded in analysis of lion faeces; the proportion of bovid kills originating from villages within the sanctuary was assumed to equal the proportion in natural kills; the maximum proportion eaten from carcasses of all types was assumed to equal that recorded when lions fed to the maximum during feeding trials.

To increase accuracy, five estimates were made of the lion population size. However, although the average estimate was probably a reasonable approximation to the true population size the range in the population estimates was quite considerable, indicating that the reliability of

the averaged estimate was not great.

Estimates made by others were within 16% of my averaged estimate. In 1970 Berwick (pers. com.) counted lions at night along roads, and recorded ten lions in a sample area of 58.1 $km^2$. By extrapolation there were c 220 lions inside the sanctuary. In 1968, the Gujarat forest department estimated 166 lions from track enumera-:tions, and 162 from visual counts of lions which came to prey that had been staked out (Dalvi, 1969).

The methods used by the Gujarat forest department for estimating lion numbers, were different from my own, and involved different assumptions. Some of these were: All lions walked along roads at some time within every 24 hours; each lion could be recognised from track measure-:ments; each track made by the right front foot was constant in size for each individual lion, irrespective of the conditions of the substrate, which varied from soft dust to stony ground; the size of track was different for each lion in each pride, and every man who measured tracks could differentiate those which were made by lion from those made by leopard or hyaena, and further, could recognise which had been made by the right front foot.

# CHAPTER 10

# POPULATION TREND

## INTRODUCTION

The aim was to provide an index of lion density in 1971 which could be used as a base against which future changes could be assessed. For example, if lion tracks were found on 500 km of road in the first survey, and on only 250 km of road in the second survey over the same ground, it might be reasonable to suppose that the lion population had decreased and possibly that the decline had been substantial, although to say that it had been halved would be to assume a direct linear relationship which might be unjustified. A more reliable indication of the population trend would be obtained by using several methods; viz. changes in the densities of lion tracks, scats and kills. Despite the relative simplicity of using an index of population size, every investigator making trend determinations of the lion population since 1936 first derived an absolute estimate of the lion population size. This was very difficult to measure, and therefore its validity was highly questionable. Each estimate was usually based on only one method; the trend was then inferred by comparing the estimate with equally questionable previous estimates.

I assessed densities of lion tracks, scats and kills. Considerable effort was made to simplify and streamline the means of gathering data in a standardised manner that could be easily repeated.

METHODS

Track recognition: Before assessing the density of lion tracks, it was necessary to develop a method for differentiating lion tracks from those of other species. They were easily distinguishable from those of horses, donkeys and cloven hoofed herbivores, but leopard, hyaena and dog posed problems. The popular conception of dis-:tinguishing lion and leopard tracks from hyaena and dog tracks on the basis of claw marks being present or absent, was not used because they were too small and often failed to leave distinct impressions on dust covered surfaces. Track shape was a better means of identification. The two lateral toe impressions of lion and leopard are round, while those of hyaena and dog are noticeably pointed. The impression of the 'plantar', (the large pad behind the toes), of both lion and leopard was rounded anteriorly and had three projections posteriorly. The plantar impression of hyaena and dog are pointed anteriorly and have two projections posteriorly (fig.50).

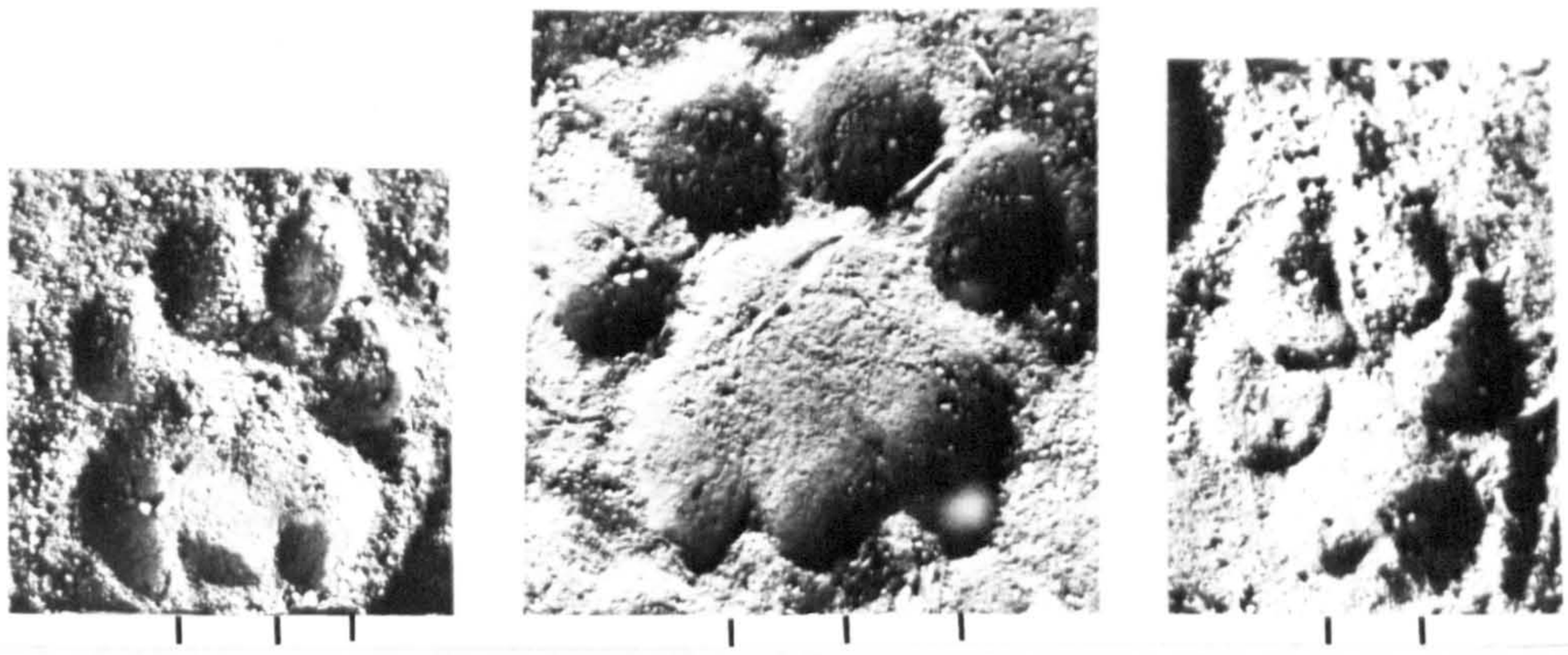


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Fig.50: Leopard, lion and hyaena tracks in that order

Separation of lion from leopard tracks was done on the basis of size. Firstly each of nine tracks of known leopard origin never exceeded 200 mm when length and width were added, while 41 tracks of known lion origin exceeded this minimum. Secondly 212 recorded tracks of either lion or leopard origin indicated a bimodal distri-:bution which separated at approximately these limits (fig.51). Almost all of the tracks falling within the leopard size range were of solitary animals, while those falling within the lion size range were frequently of animals in groups, reflecting the differences in social behaviour between leopards and lions.

Assessment of track and scat numbers: In April 1970, 275 km of road crossing all major types of habitat within the sanctuary, except hilltops, were surveyed for scats and tracks. The survey was repeated in February 1971, covering most of the routes which had been searched the previous year. It was designed so as to make the maximum use of labour in finding sign while restricting track and scat identification to myself. Each morning at dawn I stationed 4-6 men at 4-8 km intervals along a route to be surveyed; c 20 km being surveyed daily. Early morning was chosen before cattle or vehicular traffic destroyed tracks. Each enumerator marked the beginning of his route and walked the distance to the start of the next route. Every track or set of tracks which he found he marked in three ways, first by encircling with a stick,

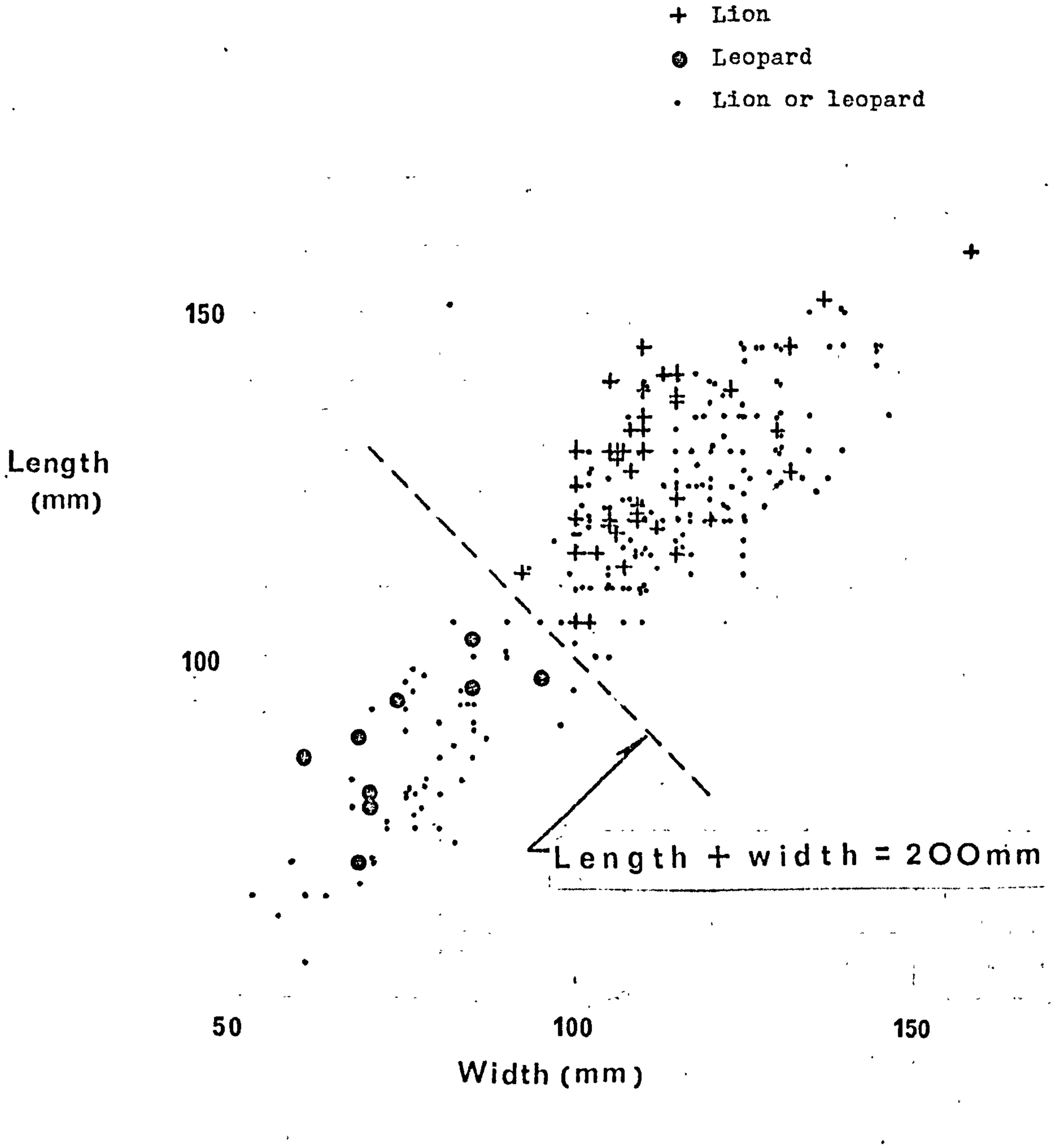



Fig. 51: Dimensions of lion and leopard tracks

then by placing a stone on top of a piece of large white paper 1 m away, and finally by tying a tag to the nearest bush 1-2 m from the ground. A distance of 1 m from the track was found necessary for placing the paper marker because small birds sometimes pecked at the paper, covering the ground with their own tracks in the immediate vicinity. The three methods of marking were used to ensure that at least one would be seen when driving at normal jeep speed (c 30 km per hour). After the men had walked their beats I drove the length of the route, stopping at each marked site to identify tracks and scats and to record the location in kms when tracks were found. I assumed that all cat tracks having a length and width totalling greater than 200 mm and all scats which had a diameter greater than 4.5 cm (see p. 46 ) were lion.

While both track and scat assessments were made along roads, and therefore had some of the same limitations, there were however important differences. Tracks recorded in the morning indicated only the presence of lions in the area in the previous night. Scats indicated the presence of lions over several days. Miss Dorothy Brewster kindly assisted me by finding that the average time taken for scats to disintegrate or be destroyed was 6.7 days in a sample of 94 initially fresh scats inspected once daily. Another difference was that the number of scats was affected by the size of pride, whereas in the method used in assessing track density no discrimination

was made between one or more lions travelling the same distance at the same time.

Assessment of lion kills: One method was to ask herdsmen the number of days or weeks since their last animal was killed. In this method herdsmen had to recall both the event and the day. Because herdsmen find it difficult to remember dates, I used another, more laborious method. Each herdsman was given a certificate and asked to participate in a scheme to record his losses. Within c 10-15 days each herdsman was visited a second time, and his losses recorded for the intervening period. Because the time interval was known, the herdsman was only required to remember whether an animal had been killed and not when. The time between visits was short to ensure that the event was fresh in the herdsman's mind, and could be confirmed. It was assumed that herdsmen would tell the truth particu-:larly as they were conditioned by an earlier survey when I inspected several hundreds of their losses. Data on the rate of killing was collected in February-March 1971 in all six districts within the sanctuary, involving 49 of the possible 135 villages. Every herdsman in each village was interviewed.

## RESULTS

Seven hundred and fifty-five kilometers were travelled for track assessments; the presence or absence of tracks was recorded in units of one kilometer; 111 km of tracks

were recorded; on average lion tracks were found in every 7.2 km surveyed.

Five hundred and fifty-one kilometers were travelled for scat assessments, and 86 scats were collected, an average of one scat in every 6.4 km. The averages for both tracks and scats did not become constant until more than 200 km had been surveyed (fig.52 and 53).

Forty-nine villages were visited twice, on average 13.3 days apart, for assessments of lion kills; 27 kills were recorded in 652 days assessed, an average killing rate of 0.55 per village, or an estimated 15.1 animals per village per year. The average killing rate per village in the time interval between visits did not become constant until more than 30 villages had been visited (fig.54). The average number of days between kills was 24, and the average did not become constant until data for more than 400 days had been assessed (fig.55).

## DISCUSSION AND CONCLUSION

An index of population density was provided as a basis for future comparisons. Tracks were found in 1 km of every 7.2 km surveyed. In order for the density of tracks to be used in determining the trend of the lion population it is essential that a constant relationship exist between the number of tracks recorded and the number of lions present. However the number of tracks which could be recorded depended on several factors. For example, the nature of the substrate determined the visibility of

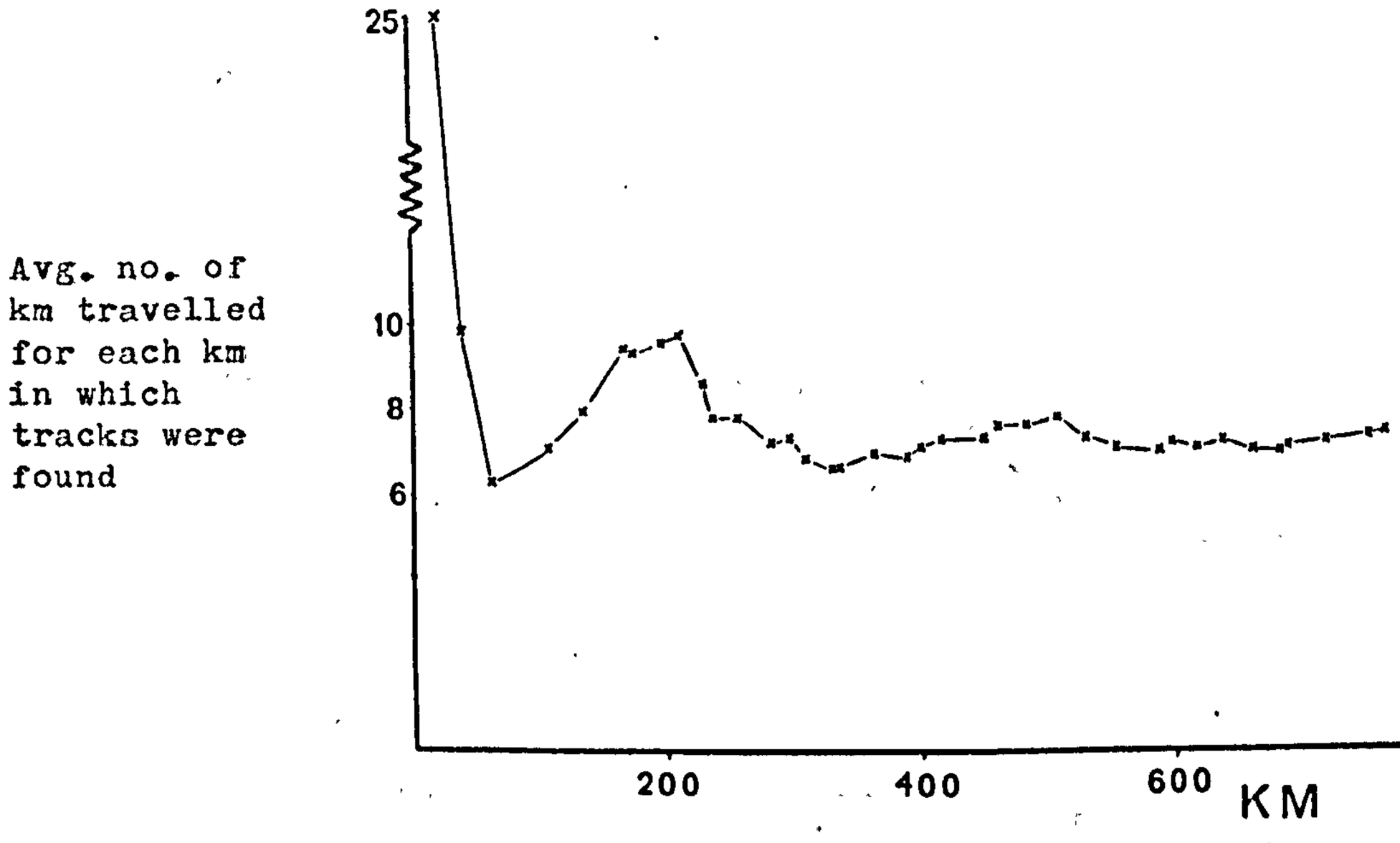



Fig. 52: Density of lion tracks in relation to distance travelle

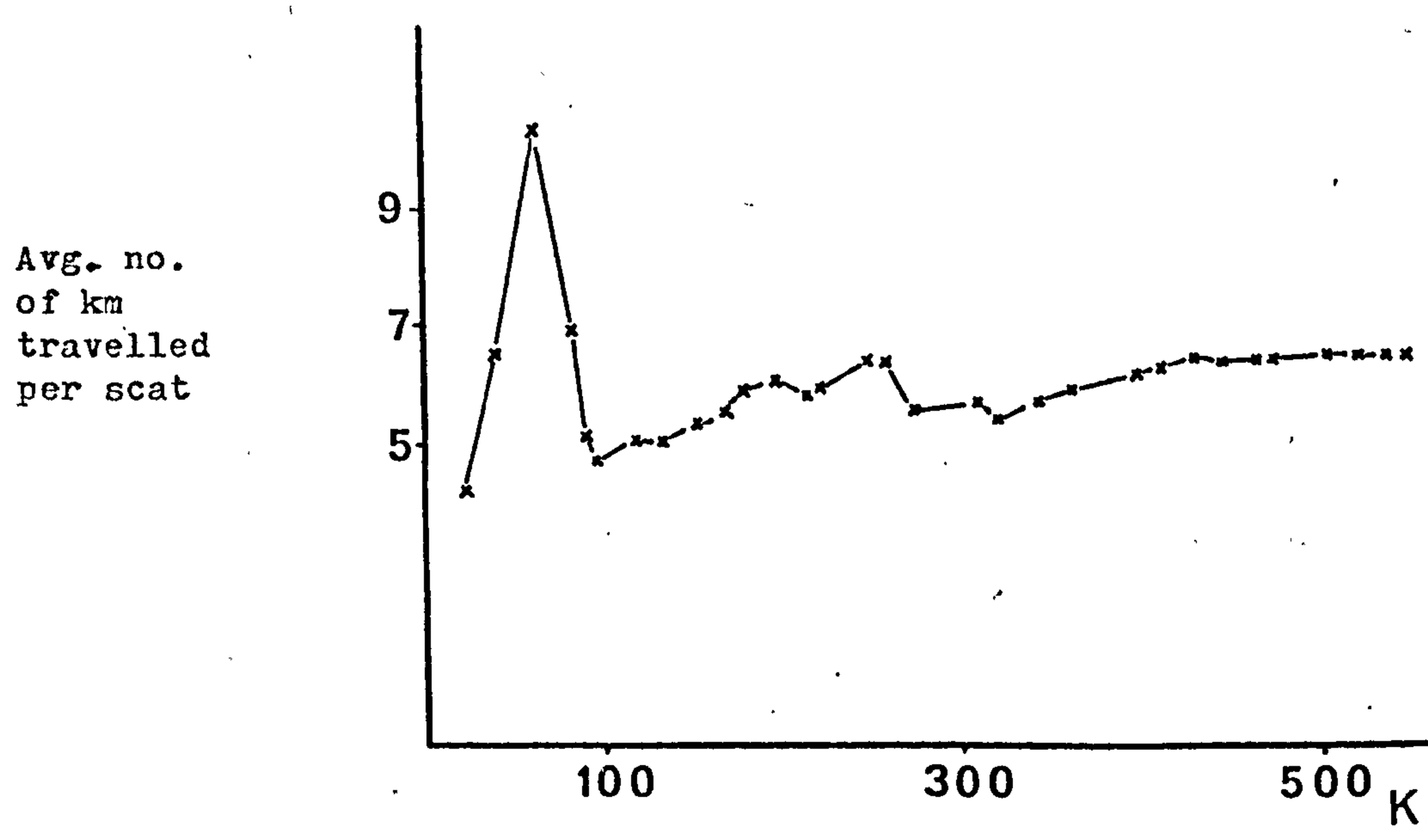



Fig. 53: Density of lion scats in relation to distance travelled

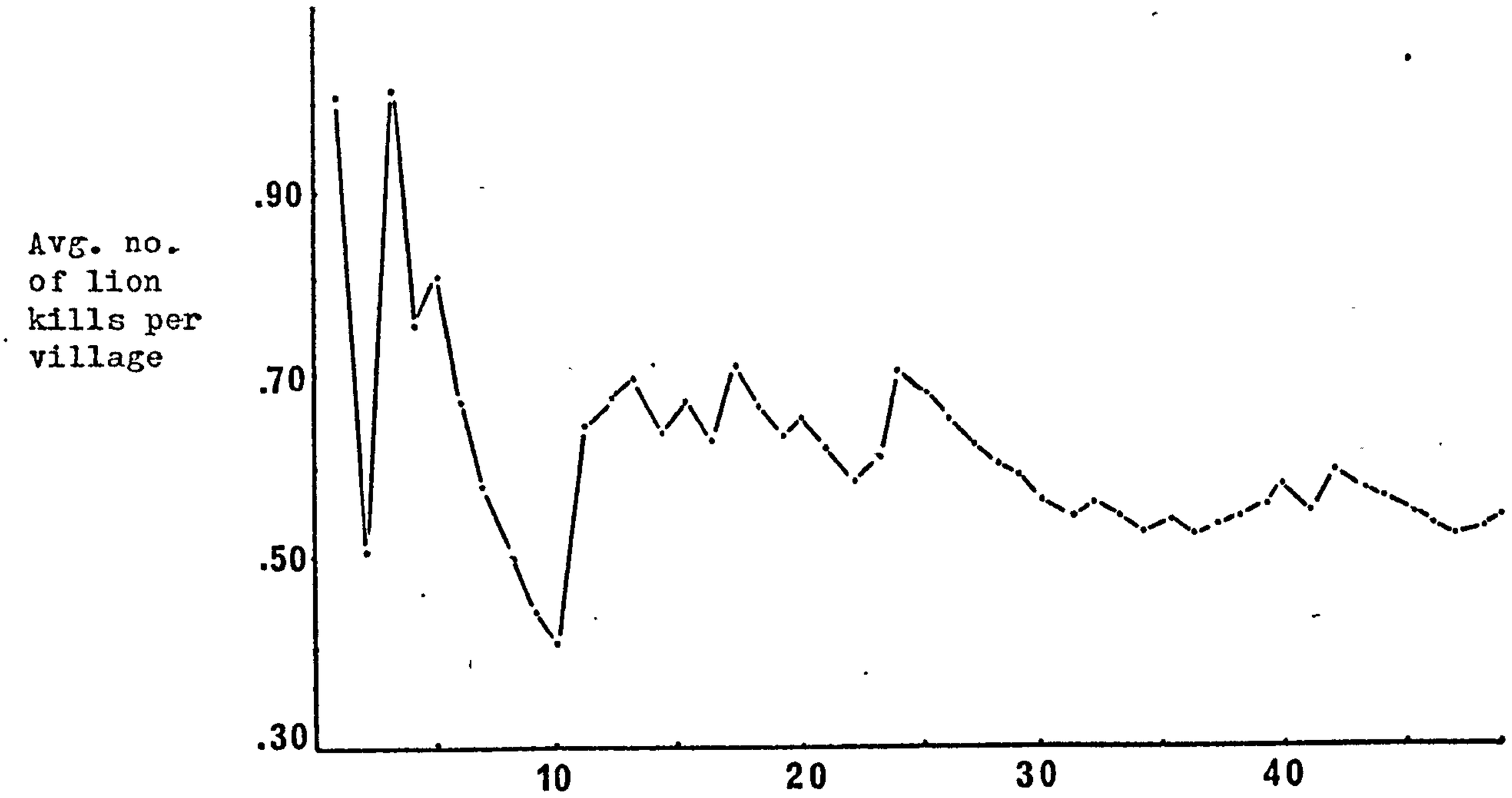



Fig. 54: Average number of lion kills per village in relation to the number of villages visited

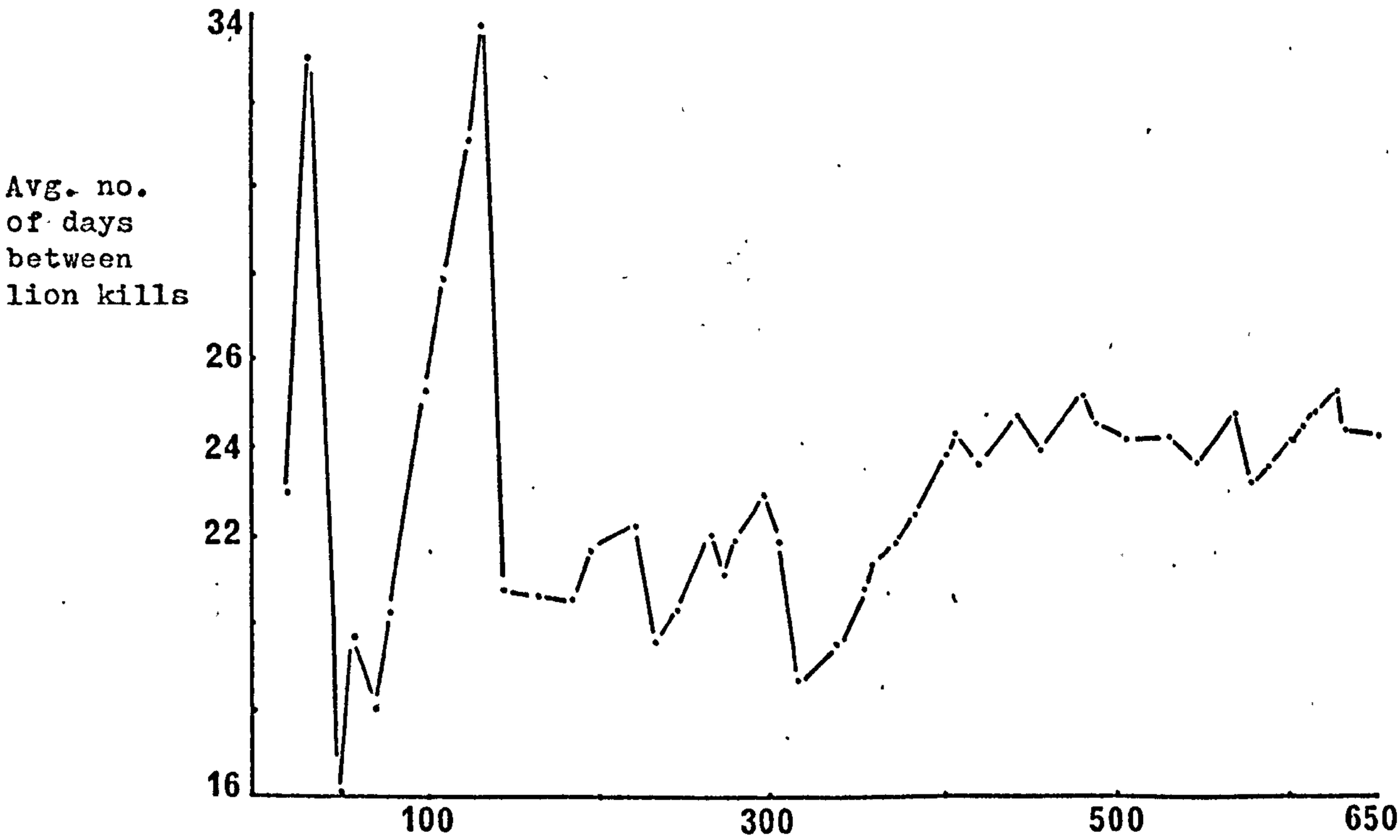



Fig. 55: Average number of days between lion kills in relation to the number of days in which the survey was done

tracks. When the ground was soft and dusty, lions sometimes left hundreds of tracks, while on stony ground only a few were visible. The presence or absence of tracks was therefore recorded in units of 1 km, assuming that any lion which walked some portion of this distance would leave at least one visible track.

Track density was also a function of topography and the presence or absence of alternative routes, such as buffalo trails and dried creek beds. Large, slightly raised roads appeared to be walked less by lions than smaller roads at ground level. Lions sometimes used roads to cross streams. They may often have travelled on roads in areas of teak forest to avoid a noisy walk over a forest floor of dried leaves. In addition the behaviour of lions also varied from making no use of roads on some nights to walking three or more kilometers on other nights. The biases could not be easily removed, but they could be averaged and made constant by increasing the total distance surveyed until local variations in track density had no significant effect on the average density of tracks recorded (fig.52).

The methods used in assessing scat and track densities ignored the influence of cubs. Lions whose scats had a diameter of less than 4.5 cm were not recorded. It was my impression that this eliminated most cubs below one year old. Young cubs were usually kept in hiding, so their tracks and scats were rarely seen along roads. When

not in hiding, cubs usually travelled in the company of lionesses and so were not detected because the method of assessing track densities did not take group size into account. Failure to record evidence of cubs means that the data can only be used to determine the trend of the adult lion population. This limitation may be highly desirable from the standpoint of management, if the stability of the lion population in the long term is more dependent upon the stability of the adult population.

Lion scats were found once in every 6.4 km, and the average number of animals killed by lions per village per year was 15.1.

# CHAPTER 11

# REPRODUCTION AND MORTALITY

## MATINGS

To find the distribution of matings throughout the year, I calculated the number of matings per 100 sightings for each month (Table 16). One mating was defined as one pair of lions seen mating per day, and one sighting as one or more lions seen at one location per day. Lions were seen mating in most months, or in approximately 5% of 1382 lion sightings. More matings were recorded in September and October than in other months.

## BIRTHS

I obtained data on birth dates of 19 litters, nine by extrapolation from my observations of cubs 1-3 months old, and 12 from reports by government personnel (Table 16). Eighty-six percent of births occurred in the first half of the year ($N = 21$; $X^2 = 10.7$; $d.f. = 1$; $p < 0.005$), with no significant difference between the two results. More matings were observed than births, indicating that many of the matings did not result in conception. Moreover there was only a weak correlation between the distribution of births and the distribution of matings at the start of gestation 3.5 months earlier.

## LITTER SIZES

The only data available on litter size at birth were from the Junagadh zoo, consisting mostly of crosses between African and Asiatic lions. The average litter size was 3.0 among 13 litters. Asdell (1964) recorded the same mean

Table 16: Number of matings per 100 sightings in each month and the number of litters born

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of matings per 100 sightings | 7 | 2 | 4 | 6 | 1 | 9 | 0 | 10 | 24 | 17 | 4 | 0 |
| No. of litters born a) extrapolated from sightings of cubs 1-3 mo. old | 1 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| b) reported by government personnel | 1 | 1 | 3 | 0 | 4 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |

among 323 births among zoos mostly in South Africa. Among cubs in the Gir between 1-6 months old, litter sizes varied between 1-4, with a mean of 2.1. Schaller (1972), similarly recorded litter sizes of the same age group varying between 1-5 cubs, with a mean of 2.2

## REPRODUCTIVE RATE

Assuming no cub mortality, an average litter size at birth of 3.0 and a birth interval of 24 months, each adult lioness should be able to raise successfully about 1.5 young per year. The reproductive history of six lionesses was recorded during my period of study. In the population sampled, females successfully raised 0.3 cubs per year. The average birth interval between 11 births was 15.4 months. This was because lionesses which lost cubs gave birth to a second litter within 7-13 months.

## CUB MORTALITY

Because few lion carcasses were found, it was difficult to measure the proportion of animals which died, and harder still to determine the causes of death. Young animals which disappeared were assumed to have died because of their dependence for food upon adults.

The average litter size among cubs seen for the first time in the field between 1-3 months old was c 30% less than the average litter size recorded at birth in captivity, and this difference was presumably due to mortality.

Of 45 lions seen in the field which were less than 18 months old, 29 were between 1-6 months, 11 between 7-12 months and 5 between 13-18 months. Assuming that the sample was typical of the whole population, 53% of cub mortality occurred between 1-6 months and 7-12 months, and another 17% between 7-12 months and 13-18 months. These results agreed reasonably well with observed losses. Fifty-nine percent of 17 cubs first seen between 1-3 months old were missing and presumed dead within 12 months after birth. These results do not include mortality at birth, for which there are no data.

ADULT MORTALITY

In three years only one adult lioness was known to have died in my study group of 16 adults; a mortality rate of approximately 2% per year. In 1963-68, 14 lions, including five cubs, were found dead by the Gujarat forest department. The most obvious reason why my estimates on cub and adult mortality are the antithesis of that reported to the forest department is because cubs which die are not as easily found as adults. In my three years I only observed one dead cub in the field, despite the disappearances of many. Because of their smaller size cubs are visually less conspicuous, deteriorate quicker, can more easily be destroyed as evidence by scavengers, and their odour during putrefaction is probably less pervasive, smell being of prime importance in the finding of most carcasses.

CAUSES OF MORTALITY

Some cubs which I observed were in poor condition, and may have been diseased or starving before they disappeared. The one cub found dead had no fat deposits around the kidneys or heart, and was extremely emaciated, suggesting starvation as the cause of death. Because of the severe losses in food outlined in Chapter seven, cub mortality by starvation was not to be unexpected. Moreover about half the dead cubs which Schaller (1972) found in the Serengeti were believed to have starved.

The importance of disease is unknown. None of the 14 lion deaths reported to the Gujarat forest department, and subsequently examined by state veterinarians, were attributed to a specific disease. The few causes of death identified were shooting and poisoning. The Sakkarbag zoo at Junagadh, which receives all lions caught in Gir, attributes the loss of them or their young in captivity mostly to gastro-enteritis, a condition commonly found in zoos (Bakshi, pers. com.). Blood smears from six of the zoo lions were sent to the National Filarial Control Unit, New Delhi, where one was found to have microfilariae. Veterinarians from the parasitology unit at Anand, Gujarat, who visited Gir, also found evidence of Spirometra sp., Toxascaris leonina, Ancylostomum

caninum, Schistosoma spindalis and Fasciola gigantica among faecal samples from five lions (Berwick, pers. com.)

Predation may also have been a cause of mortality of young cubs. However there was little substantiating evidence.

# CHAPTER 12

# ETHOGRAM

Page

## INTRODUCTION

I prepared an ethogram, a behavioural inventory (Eibl-Eibesfeldt, 1970), of the Asiatic lion, because none existed. Sinha (unpublished manuscript) described a few patterns which he observed when serving as divisional forest officer in Gir. Von Ullrich (1962) described how lions killed tethered prey, from four observations. A number of interesting accounts were given by early hunters, such as Fenton (1913). Gee (1957) and Talbot (1959) included general accounts of behaviour with other data from brief visits. Except for these few limited descri-:ptions, the behavioural repertoire of the Asiatic lion was without record.

## METHODS

Almost all of my observations were of lions which were acquainted with tourists and did not retreat when observed (fig.56). They were also accustomed to offers of live prey, usually male buffalo calves. I used binoculars and a telescope for observing and identifying lions (see p. 101). Photographic documentation was made either with a 35 mm still camera plus 400 mm lens, or on rare occasions with a 16 mm movie camera. Wherever possible, I have tried to incorporate photographic docu-:mentation into the text. I have done this because it is more accurate than the best written description (Eibl-Eibesfeldt, 1970).

A tape recorder was used in recording detailed field notes, and was particularly helpful in following behaviour patterns. Taped notes made it possible to record many generalised impressions and inferences in the field during slack periods, which might never have been recorded if left to memory to be written later. Using a tape recorder also allowed me to record lion sounds. Taped notes did have three serious drawbacks. They did not lend themselves to keeping tabular accounts, the output was voluminous, and was unsuitable for analysis without first converting to print. More than 200,000 words were recorded.

Fig.56: The lions in Gir were approached on foot.

I prepared sonograms of a number of lion sounds, using a Kay-Sonograph 7029A Spectrum Analyzer (5 - 16000 Hertz) in conjunction with a Scale Magnifier 60763. The sonograms which appear in the text can be interpreted as follows:

1. Frequency of the sound profile can be extrapolated from the vertical scales, which are divided into

units of 500 cycles per second. In the examples given (fig.57 and 58) the first 1500 cps have been marked off.

2. Intensity of sound is indicated by the density of the sonogram. The intensity is important when making comparisons with different parts of the sound, but the overall intensity cannot be compared with other sounds because the density is a function not only of the intensity of the animal's calls, but also of recording level, analyzer level and distance from animal.

3. Two kinds of sonograms are commonly used--narrow band and wide band. The narrow band gives the better picture of frequency profiles. It helps to separate the dominant sounds, and to under-:stand their source. For example in figure 57 the sound on the right contains three prominant bands or 'formants'. The upper two are exaggerated replicas of the bottom formant or 'fundamental'. The fundamental is of low frequency while the upper two are harmonics of the lower. In other words the harmonics are tones whose frequencies are integral multiples of the primary or fundamental tone. In the sound on the left the upper two formants are not replicas of the bottom, at least initially. This indicates that the start of the first upper formant is not a harmonic, but a high frequency fundamental.'

The wide band sonogram reveals the extent of 'fricative noise' added to the original sound. Fricative noise is the sound produced through friction with the sides of the mouth or pharynx when close together. Examples in human speech are the soft consonants 'hhh' and 'sss'. Fricatives are prominent in much of the lion's repertoire. In figure 58 fricatives are recognized by the innumerable vertical thin lines which extend above and below the wide formant bands, giving the sonogram a 'messy' quality.

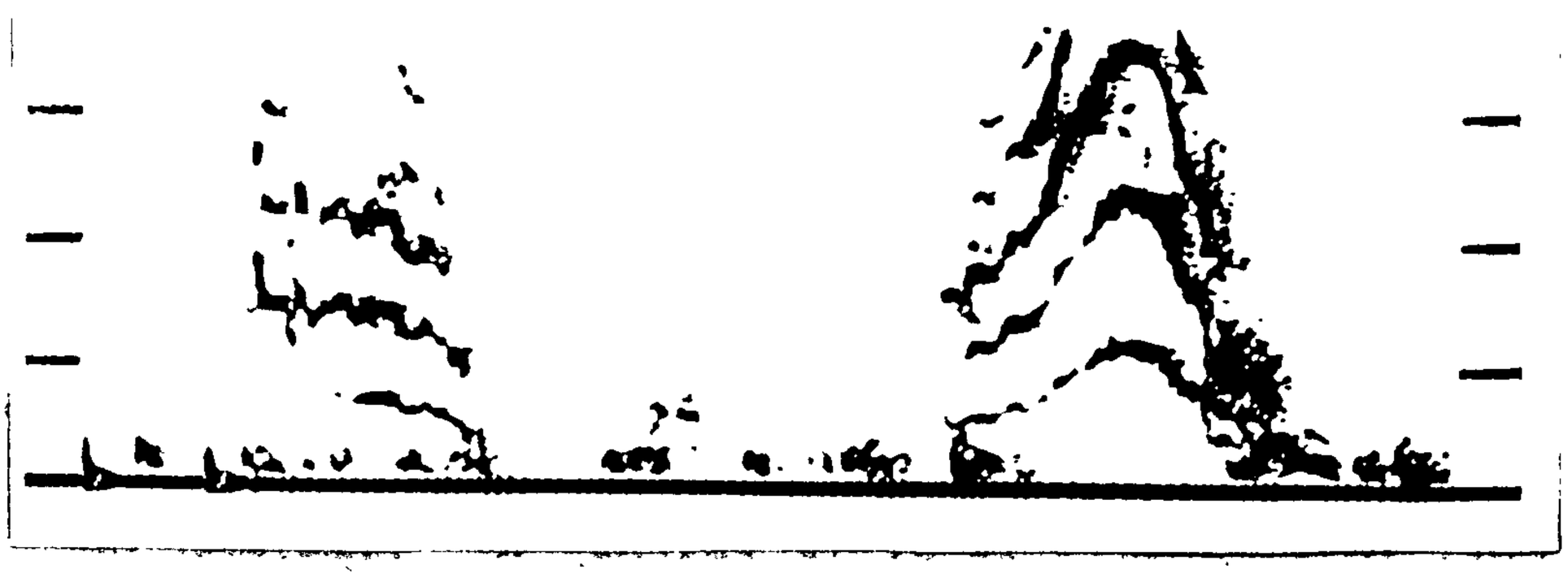


Fig.57: Narrow band sonogram of cub 'miaows'.

(They should not be confused with the base line, which in this example is unusually wide, and contains elements of machine noise). The wide band sonogram can also be used to deduce the vibration frequency of the sound source by counting the number of vertical lines which occur over one second.

4. Duration of sound can be extrapolated from the base line which is 2.5 sec in length.

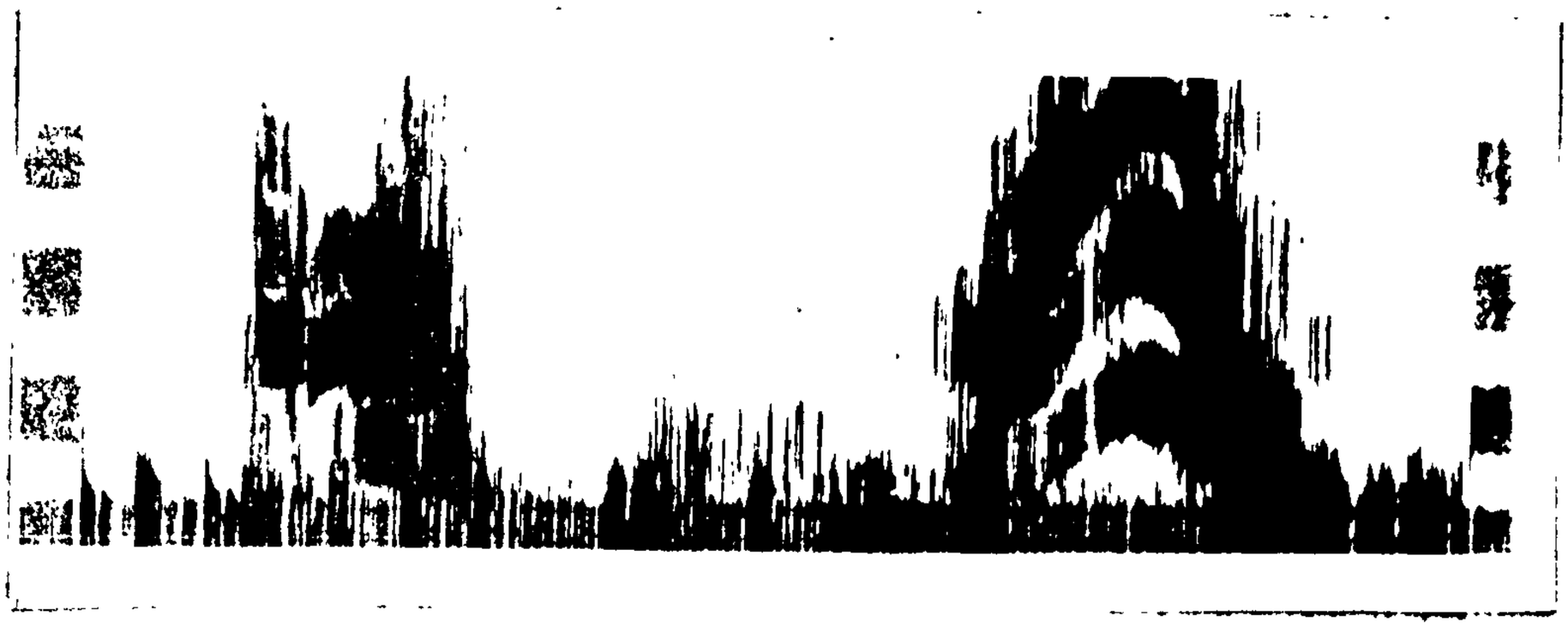


Fig.58: Wide band sonogram of cub 'miaows'.

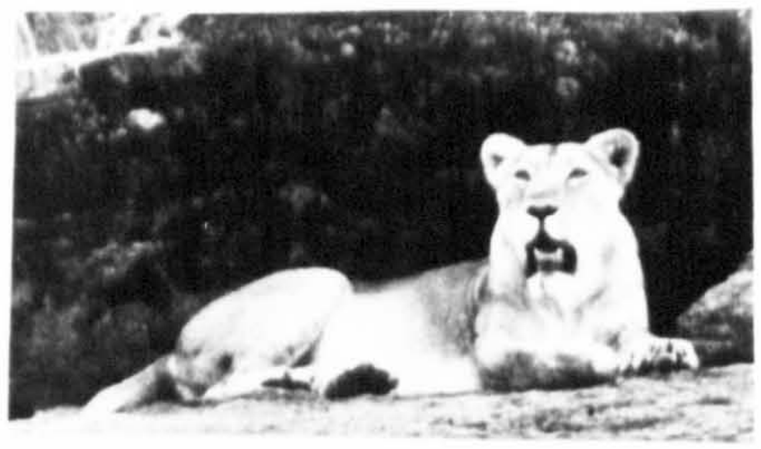
## POSTURES AND ATTITUDES

Four basic lying postures commonly assumed were sphinx, lunula, flat and splayed (fig.59). These same postures were also associated with non rest activities, such as mating, suckling young, etc.

Sphinx

a) Description: Basically a 'sphinx' like attitude. The head was raised above the line of the back, facing forward, and parallel to the ground. The body weight was distributed between brisket, abdomen and legs. The eyes were open and ears directed forward. The forelegs were parallel, and directed anteriorly. The back legs were also parallel, the lower portions close into the body, and directed forward, the hock joints touching the ground.

b) Context: A general state of alertness or readi-:ness to move while at rest. Lions close to a bait, or



Lunula

(body arced and back legs extended to one side)

Sphinx

(back legs close in, parallel to line of body)

Flat

Splayed

Fig.59: Postures assumed while resting.

to people, were found in the sphinx posture more frequently than lions lying at some distance. Moreover those lying in the lunula posture (see below) at some distance from a bait often lay in the sphinx posture after walking to within the near vicinity. Lions showing some concern at being approached sometimes changed from a lunula to a sphinx posture, as did some lions moments before attacking a bait. Lionesses with young cubs when near carcasses, people and/or other lions were observed lying in the sphinx posture more frequently than were lions without young cubs present.

The sphinx attitude was assumed most of the time when feeding, usually when making a killing bite, and sometimes when drinking. Lionesses in the act of mating assumed a sphinx posture. In contrast, I only twice observed a lion lying in a lunula posture when feeding, and never when making a killing bite, drinking or mating. It was my impression that the sphinx posture was an attitude of superior strength necessary in ripping off portions of a carcass. It could offer more mobility than the lunula posture, which might be of some importance in feeding squabbles. However, this was not the prime function when feeding, since lions often fed alone.

<u>Lunula</u>

a) Description: A lion in this attitude lay with body curved in an arc, both of its back legs to one side with the front legs directed forward. According to the

Oxford dictionary (Little et al, 1964) lunula means "something resembling a crescent shape", which is how a lion would appear if seen from above in this attitude. The weight of the body was supported by the brisket, forelegs, rump and hip. One or both front paws were sometimes curled inward, or crossed over each other. The head was raised above the level of the back, parallel to the ground, eyes kept open and ears forward.

b) Context: The lunula posture was most commonly observed when resting, except when sleeping. Lions rarely dozed with eyes shut and head dropped or resting across the forepaws. Sleeping lions usually lay flat or splayed (see below). The lunula posture was the most frequently observed posture, and was commonly assoc-:iated with lions having at least passing interest in their surroundings. In most instances the body arc and/or anterior were directed towards objects of interest or activity. This was particularly true in the case of courting lions. However there were many notable excep-:tions. Sometimes lions chose to lie in the lunula, flat or splayed position facing away from noisy tourists or lions feeding a few meters away. The apparent disinterest was, however, not always real, for such individuals were often the first to take a carcass as soon as it was left

unattended. Proximity to a carcass was often a better indication of a lion's intentions than its resting posture.

Flat

a) Description: A lion in this attitude lay on its side, with legs stretched out at right angles to the body, head resting on the ground, and eyes generally closed. Sometimes one forepaw was curled.

b) Context: Probably sleep. This posture was most commonly observed in the rest period through the heat of day, and after bouts of feeding. When lions changed from lying on one side to the other, which was not infrequent, they did so by rolling over on their back. Often the splayed posture was assumed for a time in the process.

If some minor disturbance or activity occurred, a lion might observe it with one eye, or twist its head so as to look with both, or lift its head momentarily off the ground to look over its back. However, if the activity was of interest the posture was changed to lunula, and if not sleep was resumed. On rare occasions lions lying flat pawed other lions or clawed carcasses in a manner which seemed pleasurable.

Splayed

a) Description: This attitude was the same as for flat, except that the back legs were splayed apart, one upward and relaxed, exposing the abdomen. The eyes were generally closed.

b) Context: This posture was most commonly observed

in the same periods as was the flat attitude. Lions showed a considerable discomfort to heat, and this posture may have aided in releasing body heat. This posture was also assumed by lionesses during bouts of cub suckling. The splayed posture gave the greatest access to teats. Cubs sometimes suckled when lionesses were lying flat.

Upside down

A lion in this attitude lay on its back, legs relaxed and upwards, front paws flexed, back legs splayed, abdomen exposed, head back and eyes closed. This posture was neither frequently observed, nor maintained for long. It occurred under varying conditions. Sometimes it was seen as a stage in rolling over in periods of sleep. In almost every observation following mating or post-mating aggression lionesses 'squirmed' on their backs and/or rolled from side to side, assuming a flat, splayed or upside down attitude. The experience appeared pleasur-:able. This lasted about a minute after which their posture prior to mating (lunula or flat) was generally resumed. Sometimes lions 'squirmed' on their backs, and lay upside down for no apparent reason, other than possibly a pleasurable experience. It sometimes involved social contact. On rare occasions travelling male lions smelled 'something' on the ground and rolled, squirmed and lay on it in various attitudes, including upside down.

Sitting

Unlike adult lions, young cubs not infrequently sat

on their buttocks, with front legs erect. In some cases sitting permitted cubs to see over vegetation which adult lions could already do when lying. However, the heavier the animal the greater the effort required to sit as opposed to lie. It is notable that among the other cat species, it is the smaller species which commonly sit, while the larger species lie.

Yawning

This was often seen (fig.60). It began with a lion raising its head upward, closing its eyes, directing its ears backwards, opening its mouth and protruding its tongue downward. It was followed by the upper lip being raised, exposing all the upper teeth. As yawning termi-:nated the head returned to the horizontal, the eyes opened, the ears brought forward, tongue retracted and mouth closed. There was a visible shudder of the jaw just before closing and one side of the jaw invariably shut before the other. There was no consistency as to which side of the jaw would close first.

Yawning by one lion sometimes resulted in others doing the same. It was usually observed before and after periods of deep rest. According to Ewer (1968), yawning has been ritualized into a threat among some mammals. It is not irrelevant, because it displays the teeth, the animals most dangerous weapons (see p. 215 ). Kleiman (1966) has shown that some carnivores when threatening, enhance the display by raising the upper lip, fully

exposing the upper canines. Asiatic lions in the second stage of yawning always lifted the upper lip. None the less, if lions used yawning as a form of threat it was not readily apparent. I never witnessed a lion retreat after another lion had yawned. Schaller (1972) was also unable to find any evidence that yawning in the Serengeti lion constituted a threat.

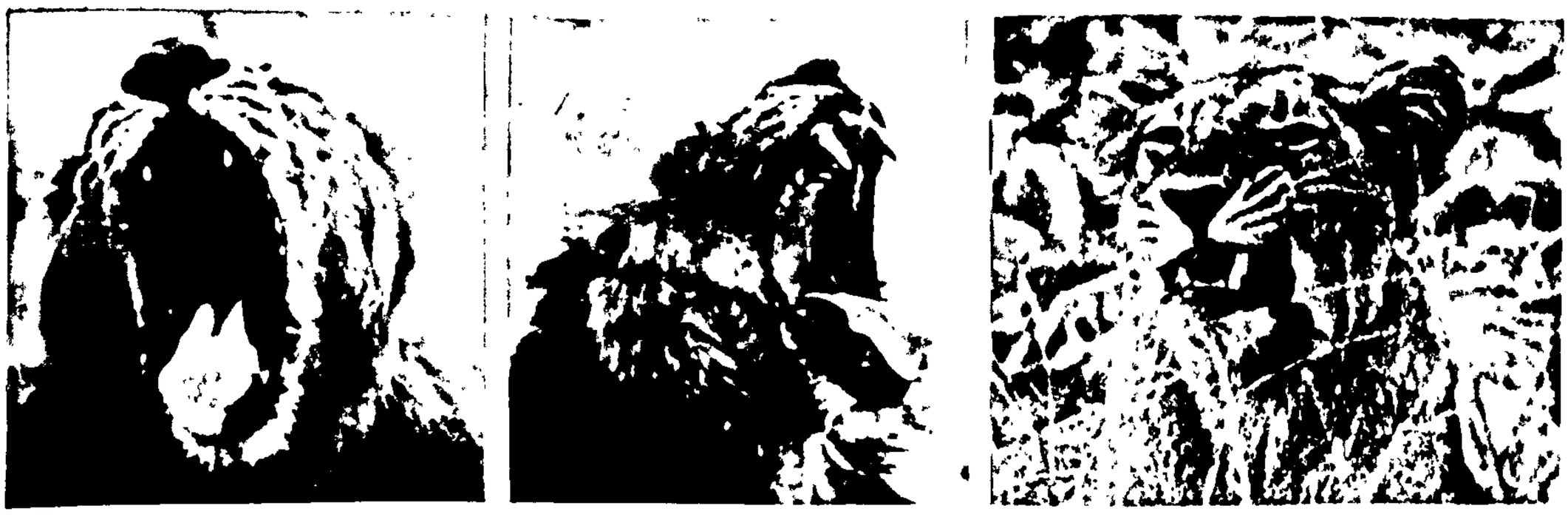


Fig.60: Three stages in the yawning process.

Stretching

While lions usually yawned when lying in the lunula or sphinx postures, stretching was observed when standing. With front legs out-stretched, the forequarters were lowered into a deep arch, head upturned, ears forward and mouth closed. Lions which rose up after a period of rest sometimes stretched. It was not a commonly observed behaviour.

I twice observed stretching after thwarted attempts to approach. One instance involved a game keeper sitting

on the ground with a goat tethered 1 m in front of him, while 3-4 m behind lay an adult male lion in the sphinx posture with obvious interest in the goat. Every time the lion rose with the intention of moving towards the goat the game keeper waved his arm vigorously downward towards the lion and called. This was enough to stop the lion, which then stretched, and lay down again. This series of events was repeated a few times.

The second occasion was very similar. An adult male lion rose, took a few steps towards a buffalo, and then was prevented from moving closer by a game keeper who attracted attention by slapping a stick a couple of times against the ground. The lion stretched, then walked over to another lion and rubbed heads.

Schaller (1972) observed that in the Serengeti plains, where trees were rare, lions sometimes clawed the ground while assuming the stretch posture.

Self grooming

Nose licking was probably the most frequent grooming behaviour exhibited. It took less than a second and went unnoticed most of the time. Nose licking occurred in all nine cine recordings of lions changing to the lunula or sphinx posture from a standing position, and there was no reason to suspect that these observations were not typical. It was observed after bouts of head rubbing, scratching, and on numerous other occasions not particularly associated with any other activity. It was seen during parallel

walking by both participants.

In licking other parts of their body, considerable attention was usually given to the forelimbs, face and neck, while only to a lesser extent to the sides, back and genitals. The face, neck and forepaws were the parts commonly blooded during feeding, so the preferences were practical. Cleaning the face was achieved by rubbing the muzzle, chin or side of the face across a foreleg, or rubbing the side of the foreleg across the face, and then licking the leg a few times (fig.61). This procedure was usually repeated several times. It was effective in removing blood. This behaviour is common to felids. Ewer (1967) has recognised that the use of the side of the foreleg, rather than the paw, as is common among rodents, may be an adaptation to protect the animal from clawing its face, particularly because in young domestic cats the claws are non-retractile.

Fig.61: Use of forelimb in self grooming.

To clean the underside of the neck the chin was arched inward and the tongue extended around it. In all self licking of parts other than the face the head was moved while drawing the tongue. The strokes were always

in the direction in which the hair lay. Face, neck and forepaw cleaning was achieved while lying in the lunula or sphinx posture. In licking the back or genitals lions used the front legs to support the forequarters. On rare occasions lions licked parts of themselves, including the back, while lying flat.

Sixteen of 41 occasions when self licking was observed occurred after lions had fed. There were no other major associations beyond that of resting. Self licking was basically an adult activity; 35 of the 41 observed occasions being associated with adults.

Other maintenance activities were commonly associated with self licking. Sometimes lions nibbled parts of their body with their incisors, in what was probably an attack on external parasites. They sometimes nibbled and cleaned a paw while standing if they had stepped on a thorn. Injuries were cleaned by licking. Injuries to the head were sometimes rubbed against the ground or laid upon occasionally in such an awkward manner as to leave no doubt that the behaviour was intentional, possibly to keep injuries free of flies. However I also observed this when flies were not about. Injured lions sometimes rid themselves of flies by running a short distance through bushes. A single fly was often sufficient to rouse even an uninjured lion from rest, resulting in a watch of the fly's movements, 'snaps' of the mouth in an attempt to catch it, changes in position and possibly even location.

Lions occasionally used a back leg to scratch either

their sides, back of the head, ear or chin. They sat when doing so. Except when scratching under their chin, they put their tongues out and licked the air while scratching. This apparently functionless behaviour was common to adult and young, male and female. I once observed a young cub do this when licked along the back by its mother.

Lions sometimes scratched their bodies or heads against something so as to relieve minor irritations. Sometimes objects such as trees, bushes, lions and rarely carcasses, were rubbed sinuously against or through in what appeared to be a pleasurable experience. Sites that were sprayed were always preceded by such behaviour (see p.208). As with the house cat, each part of the body which came in contact was exaggerated, particularly the nose, back of the head, back and tail if the object was above; and the cheek, side and tail if the object was lateral.

Tree clawing

On seven occasions lions were observed clawing trees. In each instance a lion walked up to a teak tree, stood on its hind legs, and looking upward, leaned into the tree (fig.62). Repeated clawing was slight compared with that often observed among domestic cats. After a few seconds the lion descended. On two occasions more than one lion was observed clawing the same tree. Young cubs were twice observed clawing trees.

According to Leyhausen (pers. comm.) cat claws grow in sheaths, and the function of clawing trees or posts is

to remove the worn, blunted outermost sheath. Among small cats, Leyhausen has observed discarded sheaths at such sites.

Among the smaller cat species Leyhausen has also noted that this behaviour is used by the males as a form of intimidation or threat. I did not observe adult male lions clawing trees. De Leeuw (vide Lockie, 1966) has noted that, in the wild cat (Felis silvestris), tree clawing leaves not only a visible mark, but also carries the scent of a foot secretion.

Fig.62: Tree clawing.

## SOCIAL INTERACTION WITHIN THE PRIDE

### Head rubbing

The most common form of friendly encounter between adult or near adult lions was head rubbing (fig.63). Typically one lion would walk up to another, touch noses, then rub the top of the head, muzzle or cheek across either the nose, cheek or top of the head of the other individual. Commonly the initiator would twist its head so as to expose its dome before making contact. The experience appeared

Fig.63: Typical sequence in head rubbing

to be pleasurable. Sometimes the initiator made a low 'mmm' before making contact. Adamson (1961) and Schaller (1972) also reported hearing such sounds. The duration of head rubbing was generally brief (7-8 sec). Sometimes it was repeated after a pause of 10-15 sec. In 80% of 66 encounters the initiator was recorded standing while the recipient was lying.

Head rubbing alone was involved in 68% of 76 cases involving adults. In the remainder it was accompanied by other friendly acts, such as one or the other licking (9%), the recipient rolling over on its back and gently pawing the face and side of the initiator (9%), one lion rubbing sinuously along the side of the other (7%) or some combina-:tion of these additional acts (3%). On three occasions one lion lay on top of another following a bout of head rubbing. The side or rump was allowed to fall across the other, resulting in obvious momentary discomfort to the recipient. Lions sometimes licked, pawed, rubbed sides or lay on each other without also rubbing heads. However, with the exception of licking, particularly common between lionesses and their cubs, such occasions were infrequent.

Ninety-one percent of 78 head rubbing sessions invol-:ving adult or near adult lions were between lionesses. Adult male lions rarely indulged in head rubbing. However in six of the seven occasions when head rubbing was noted it was between two adult males. There were a number of occasions, exclusive of courting, when lionesses and cubs

showed great interest, perhaps even curiosity, in adult males, touching noses, attempting to smell their posterior, rubbing sides or pawing at their legs. However most contacts between adult males and females exclusive of courting were sharp, aggressive and subordinating for the lionesses.

According to Leyhausen (1960) greeting is a ritualized form of sexual behaviour. On two occasions Schaller (1972) noted that greetings between males led to intense caressing and finally to homosexual mounting and thrusting, intimating to him a close relationship between the two patterns. I also once saw greeting between males leading to homosexual behaviour, However, most greeting took the form of head to head contact between cub and mother rather than between consorts. Licking, gentle biting, rubbing sinuously under the chin and pawing were also commonly seen between cub and mother. Head rubbing was relatively uncommon between courting pairs. Usually lionesses initiated mating, and always gave low prolonged growls before and during mating. Males were generally aroused by females merely rising or growling.

Nearly always cubs initiated head rubbing with lionesses, usually with their mothers. Similarly in 37 of 44 occasions involving only lionesses, it was the younger ones which initiated contact with older ones, and in the majority of these situations it was a daughter to mother contact.

Head rubbing was correlated with hierarchy. In 36 of 43 occasions involving lionesses the more subordinate individuals initiated it. (Dominant and subordinate individuals were recognised by their possessive or sub-:missive attitudes in encounters over food.) However, with a few notable exceptions, subordinate individuals were also younger, so the results were one and the same. Schaller (1972), in contrast, reported that among the Serengeti lion "females readily rub and lick cubs and vice versa without indication that the activities are related to dominance per se". He could find no evidence that such contacts were related to a hierarchy.

Lionesses sometimes rebuffed attempts at head rubbing either by baring their teeth (fig.84) or snapping. On one occasion a rebuff took the form of calling repeatedly into each other's face. Schaller (1972) also noted lionesses refusing to rub heads by baring their teeth.

Head rubbing occurred in various circumstances. As Schaller observed, it often happened on the arrival of a lion. Irrespective of the age of the arriving lion, it was usually the younger that initiated the greeting.

Head rubbing sometimes followed when a lion or lioness had difficulty in tackling a bait. On some occasions failure to bring down an animal resulted in a lion giving 'syndetic' calls, looking to other lions, walking to them, possibly head rubbing, and returning to the bait. It seemed reasonable to infer that these were attempts to

summon assistance. However its effect was questionable. The response was never immediate. Moreover, assistance, when needed, usually came eventually without having to be summoned.

Schaller (1972) observed that head rubbing sometimes followed aggression. In my experience this was most common among cubs which had 'lost-out' during feeding squabbles. They frequently walked immediately towards their mother or another amicable sibling, giving the syndetic call, and sometimes following it by head rubbing. I once observed an instance of head rubbing between a male and female within six seconds after a serious bout of post-mating aggression. This remarkable change in mood was documented on cine film.

On three occasions lions rubbed heads with one which had just made a kill.

When lions fed on buffalo calves they commonly did so one at a time. On three occasions when one lion left a carcass to rest, it rubbed heads with another lion which subsequently appropriated the carcass.

On two occasions lions attempted to indulge in head rubbing to prevent others from feeding; an attempt associated with parallel walking (fig.73 and 74). The function in these instances seemed to be to constitute a deterrent in the form of a non aggressive obstacle.

Most amicable contacts between lions of the same sex or between adults and siblings were directed 'head to head'. Non-sexual physical contacts between adult males and adult

females were rare, and in contrast often involved anal sniffing. Although Schaller (1972) did not specify that anal sniffing was primarily between the sexes of Serengeti lions, the examples that he described were of this type.

Mutual grooming: One lion often licked another's head and neck briefly. In 26 of 42 recorded cases this occurred between adults and cubs, with adults the initia-:tors in 35. Similarly, adults were involved in 35 of 41 cases of self grooming and in 10 of 14 cases where adults groomed adults or cubs groomed cubs. I did not observe adults grooming adults of the opposite sex, except when copulating, when male lions sometimes made a few perfunc-:tory licks at the necks of lionesses. Mutual grooming and self grooming were confined to periods after feeding in 24 of 42 observations.

Syndetic call

Of the variety of sounds which lions make, only one amiable call was recorded in the context of bringing two lions together. I have named it the 'syndetic' call because according to the Oxford dictionary (Little et al, 1964) 'syndetic' means "serving to unite or connect". It was heard when cubs searched for their mothers, when mothers called and their cubs came, and when either an adult male or female called in the direction of another lion of the same sex, which then came and assisted in bringing down prey. It was sometimes heard immediately following a bout of aggression when a subordinated individual, usually a cub, went to another

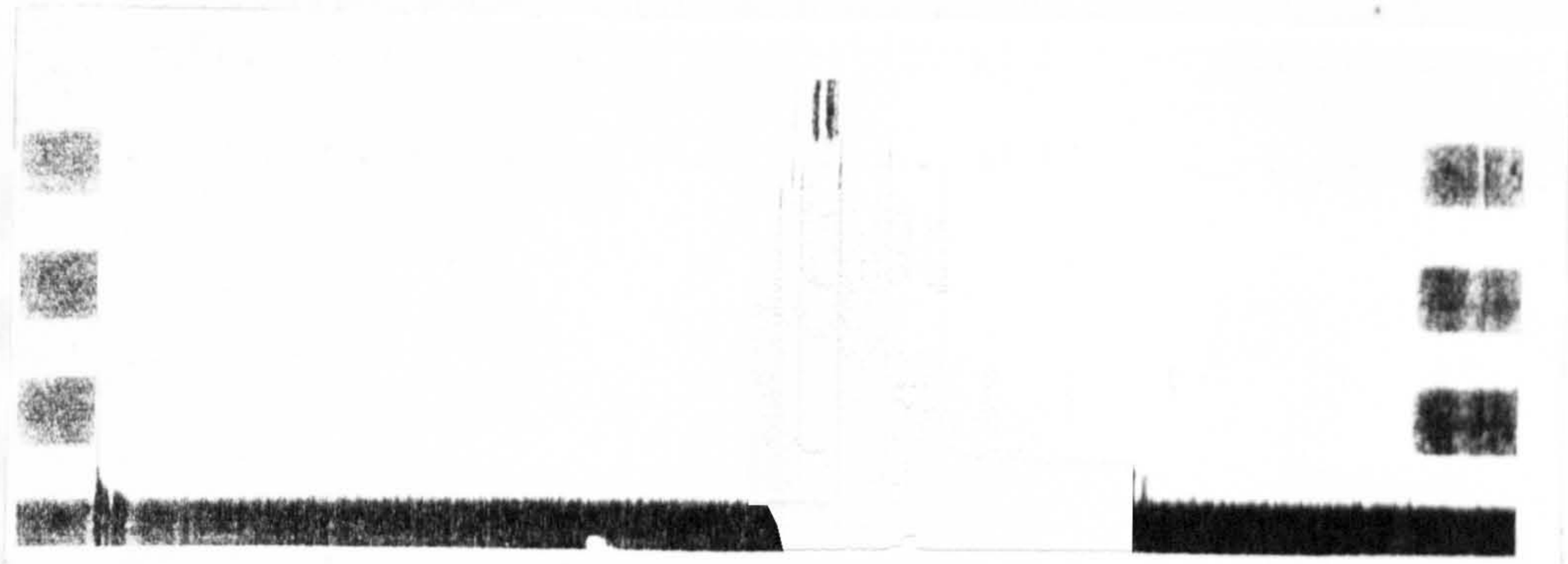
more amicable lion. The call was usually repeated a few times. A lioness in some distress while actively search-:ing for a lost cub, sometimes repeated the call for ten minutes or more. The intensity was varied, depending on the situation. A lioness searching for a persistently lost cub called much louder than one which was immediately answered. When, on rare occasions, the call was made just before head rubbing, it was just audible.

The sonograms recorded a sharp drop in pitch, a characteristic not found in other calls made by adult lions (fig.64 and 65). The length of call ranged between about 0.2-0.7 sec. It had no easily describable analogy, such as a cough, grunt, growl or roar. Guggisberg (1963) described a lioness calling 'moah' to her cubs, which then came. Adamson (1961) described it as 'mhn' for one lioness and 'tciang' among cubs. This illustrates the difference in the first pair of formants between the two ages. There is also less fricative noise (friction on the sides of the pharynx) when the call is made by a cub. Schaller (1972) described a call occurring in similar circumstances as indistinguishable in sound from a prelimin-:ary roar (soft roar). I did not find this, because of the descending pitch in the syndetic call. However, the sonogram of the call contained in Schaller's book bears little resemblance to those which I recorded for the Asiatic lion.

Courting

Asiatic lions commonly courted for 4-5 days. During

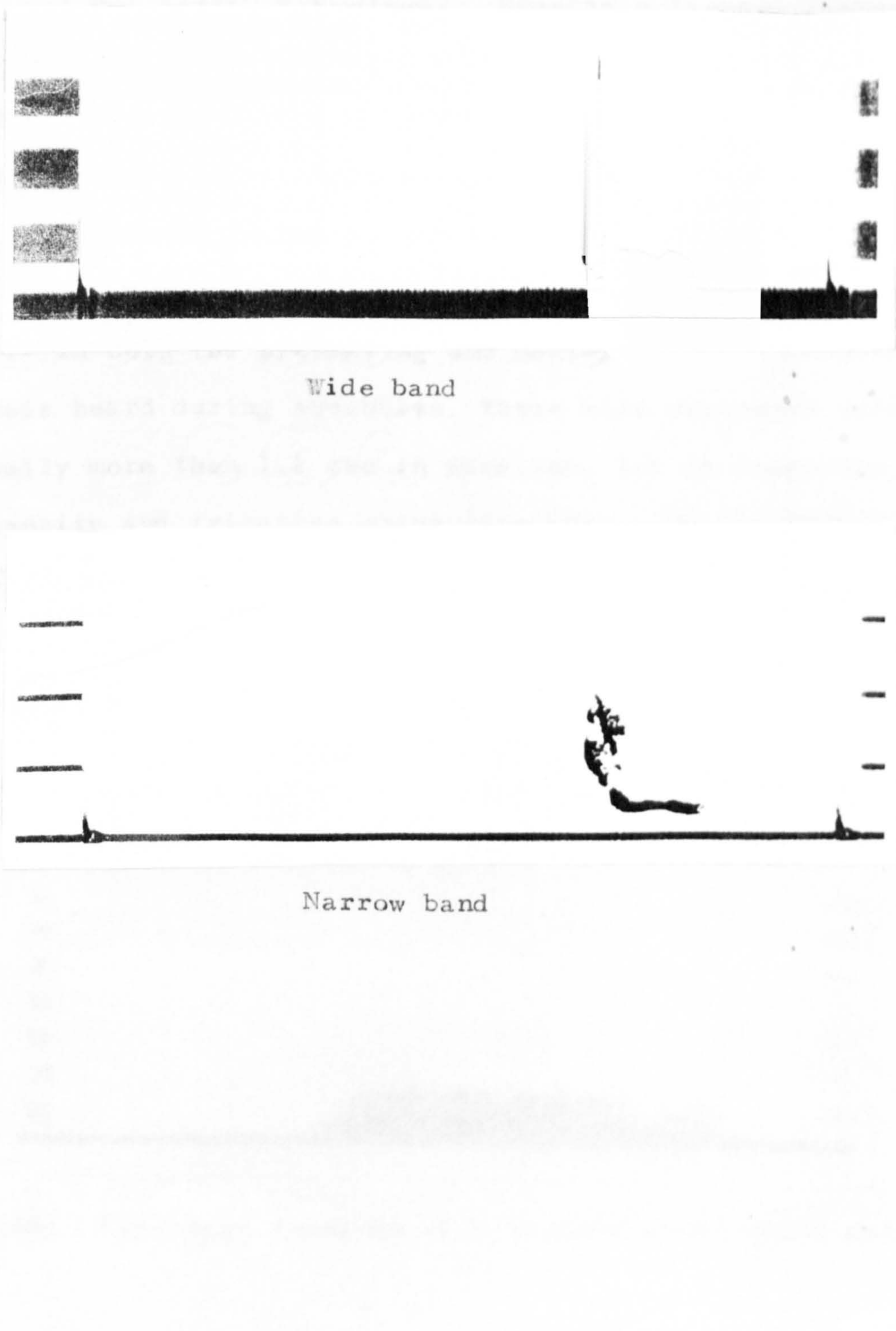
Fig.64: Sonograms of an adult lioness giving the 'syndetic call' while searching for her cubs



Wide band

Narrow band

Fig.65: Sonogram of a cub approximately six months of age giving the 'syndetic call' while searching for its mother



Wide band

Narrow band

this time they usually moved little more than a few hundred meters. Mating was frequent, and sometimes as often as every 10-15 min. While male lions stayed close to females, usually within 4-5 m, it was the lionesses which commonly initiated mating.

a) Pre-mating behaviour: Usually a lioness looked at the male while both were at rest. She began growling and rose either before or after the male had done so. If the male rose first, it appeared to be at the initiation of the lioness, either by her looking at him beforehand, or by her growling, or both. Lionesses growled continu-:ally in both the pre-mating and mating stages. Unlike growls heard during squabbles, these were prolonged rolls, usually more than 1.2 sec in duration, low in frequency, intensity and fricative noise (fig.66). During mating the intensity of each growl slowly increased, the growls being sufficiently distinct from those heard at other times to enable courting lions to be readily recognized.

Fig.66: Wide band sonogram of a lioness growl while mating

After rising she sometimes made nose to nose contact, rubbed sides and/or directed her posterior towards the male (fig.67), before moving a short distance and allowing herself to be mounted. More commonly however she made little if any physical contact with the male before allowing herself to be mounted. On occasion, particu-:larly when disturbed by observers, she trotted 100 m or so before being mounted. Her prolonged growls continued while trotting, and acquired the superimposed 'beat' of her pace.

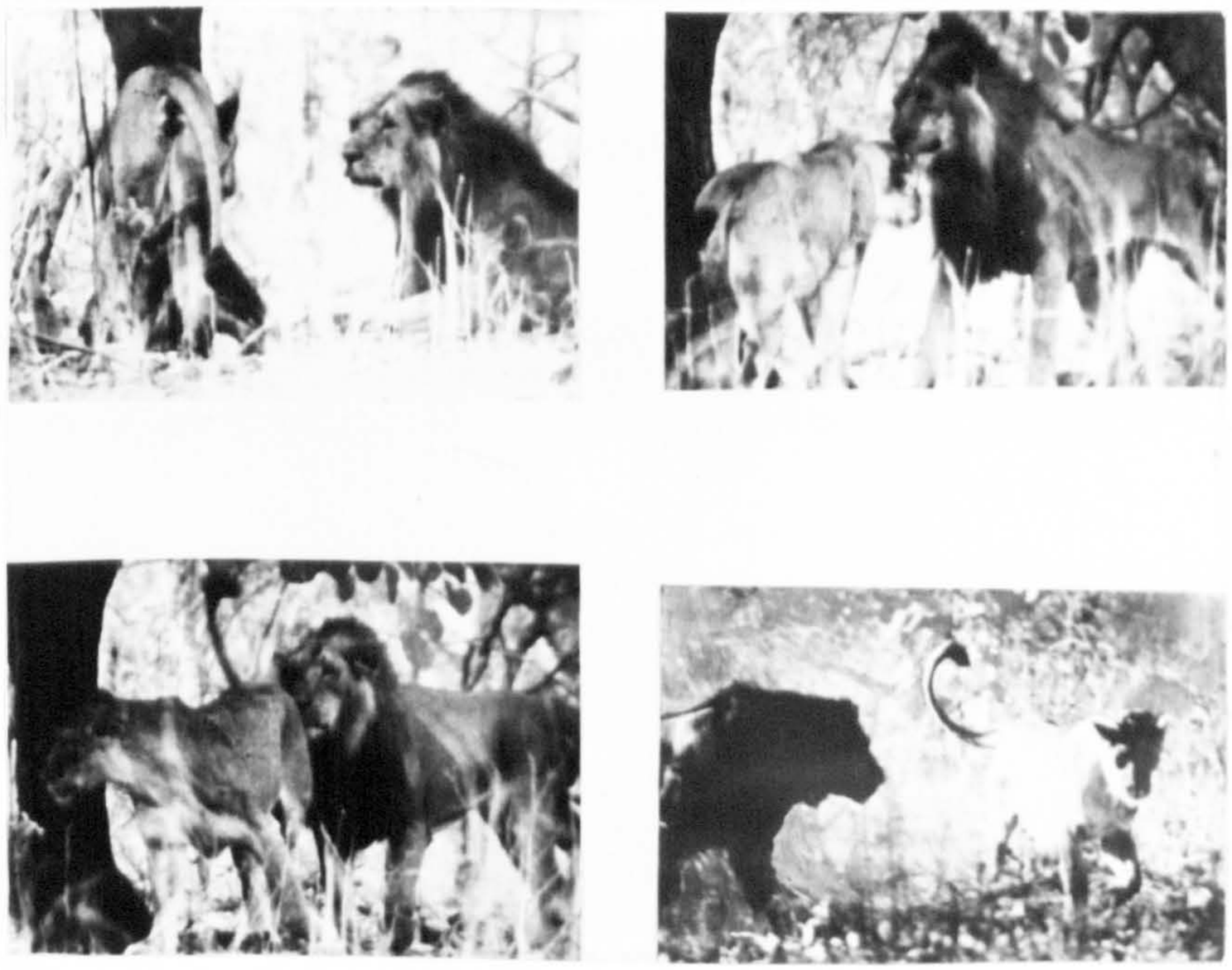


Fig.67: Pre-mating behaviour

b) Mounting: Lionesses 'presented' the sphinx posture before being mounted (fig.68). Males almost always stepped over the back rather than walking on from behind. The lioness's tail was turned at an angle at its base so as to assist entry of the penis. In mounting

and mating, the male's head was turned sharply downward a few centimeters over her withers, with ears back and eyes partially closed.

Fig.68: Mounting

c) Copulation: The male assumed a near sitting posture, supporting the weight of his hind quarters on his hocks. While thrusting, his closed mouth expression remained unchanged (fig.69). Though continually growling, the lioness sometimes looked around with ears forward, and gave the impression of not always being fully involved. As climax was reached the male's thrusting ceased, and he pressed his posterior against hers. His face wrinkled, his mouth opened wide, and he often rotated his head as if about to bite her neck. The experience appeared agonizing, and was commonly accompanied by a high

Fig.69: Thrusting and pressing during copulation

pitched and distinctive scream audible at times up to 500 m. Usually it consisted of a burst of two or three calls, each lasting less than a quarter second (fig.70).

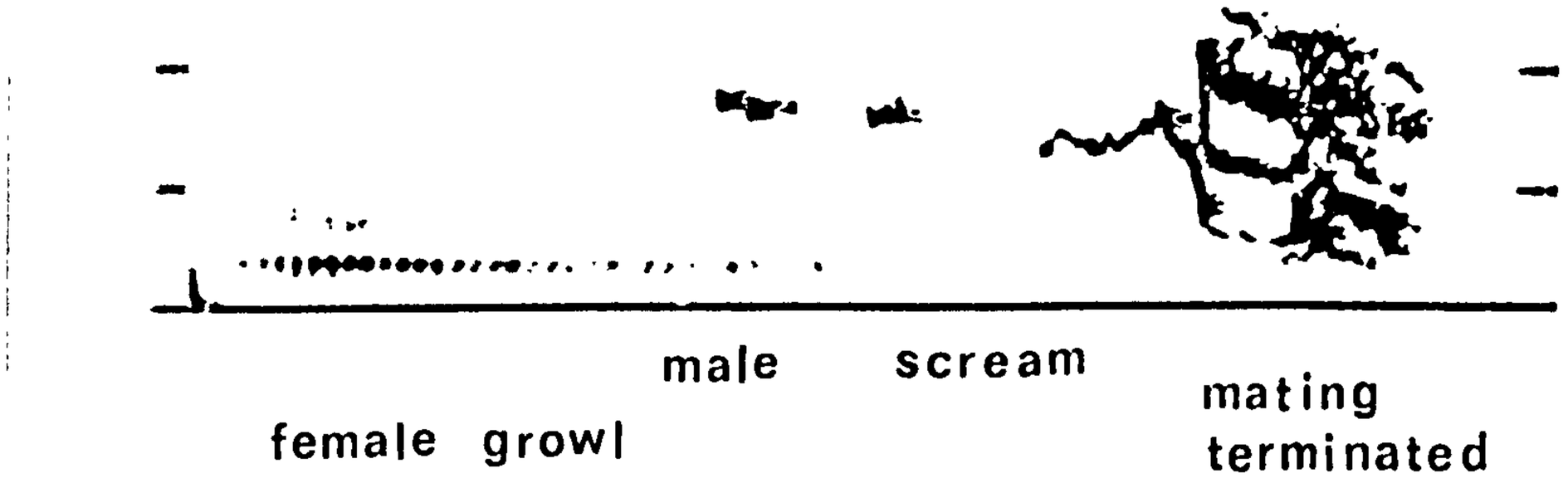



Fig.70: Narrow band sonogram of lion sounds when mating

However sometimes the sound was sustained for 4-5 sec (fig.71). I never heard males scream except when mating. At night these sounds often enabled me to locate courting lions.

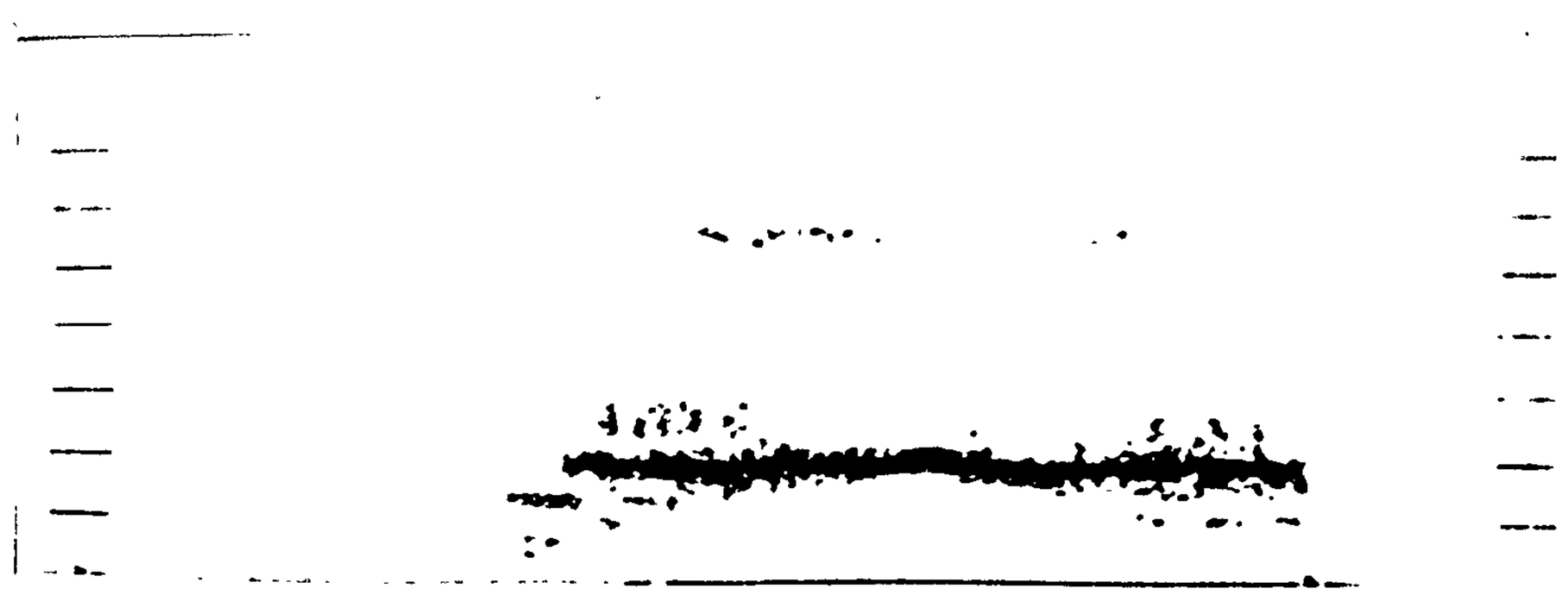


Fig.71: Narrow band sonogram of the beginning portion of a sustained male scream during copulation.

Mating among Siamese cats is accompanied by a screeching cry from the female and a growl from the male (Ewer, 1967). In Asiatic lions the converse was the rule. On the first occasions I mistakenly thought that male lions growled and females screamed, but subsequent closer observations revealed that this was incorrect. Could Ewer have made the same mistake?

Schaller (1972) observed that male Serengeti lions miaowed when copulating, but made no reference to their screaming. This difference between our findings probably reflects ambiguities in our terminology. His sonograms of miaowing in lion cubs show that he included a great variety of irregular sounds ranging from those with a constant frequency in the 1-2 kHz range, and which I would call screams, to calls characterised by a modulated frequency with most of the sound energy below 1 kHz, which I would term miaows.

As the male pressed, the lioness extended her head forward, her ears back, and appeared to be in some dis-:comfort. Sometimes the male barely touched her neck with his teeth, but did not appear to bite. Cooper (1942) observed lionesses in captivity being held by the scruff of the neck when mated. Mr. Peter Jackson kindly sent me a photograph of a tiger firmly holding the skin of a tigress between his front teeth perhaps ten cm above her neck while mating. Mr Narish Bedi also showed me photographs of similar behaviour in another tiger mating.

Antonius (1943) has recorded it among jaguars (Panthera onca), pumas (Felis concolor) and the North American lynx (Lynx canadensis). According to Ewer (1967) neck biting is common among the smaller Felidae, but vestigal among the larger cats. I did not observe Asiatic lions take a firm bite of a lioness's nape during copulation. Among Serengeti lions Schaller (1972) usually observed only light biting.

d) Post mating behaviour: The termination of mating was abrupt and usually involved some amount of aggression by the lioness directed towards the male. Once her aggressive interlude was over, which usually lasted only a few seconds, the lioness either rolled around on her back or lay flat (fig.72). Her attitude suggested that she was experiencing a pleasurable sensation. This normally lasted from 30-60 sec. On rare occasions she did not do this, but trotted some distance away. Twice, near the end of courting, I observed a lioness go directly to a carcass and start feeding for a moment or two after mating. Male lions always stood for 30-60 sec or more. They were more aware of their surroundings then than at any time during mating, and sometimes behaved belligerently towards man. Sometimes they roared. Schaller (1972) observed that Serengeti lionesses usually rolled on their backs immediately following mating, but made no reference to a male characteristic to stand.

After this brief period the male usually resumed the

posture adopted before mating began, such as lunula or flat. Although the lioness also resumed her original posture, they acted independently. I have twice seen the same behaviour in captive leopards.

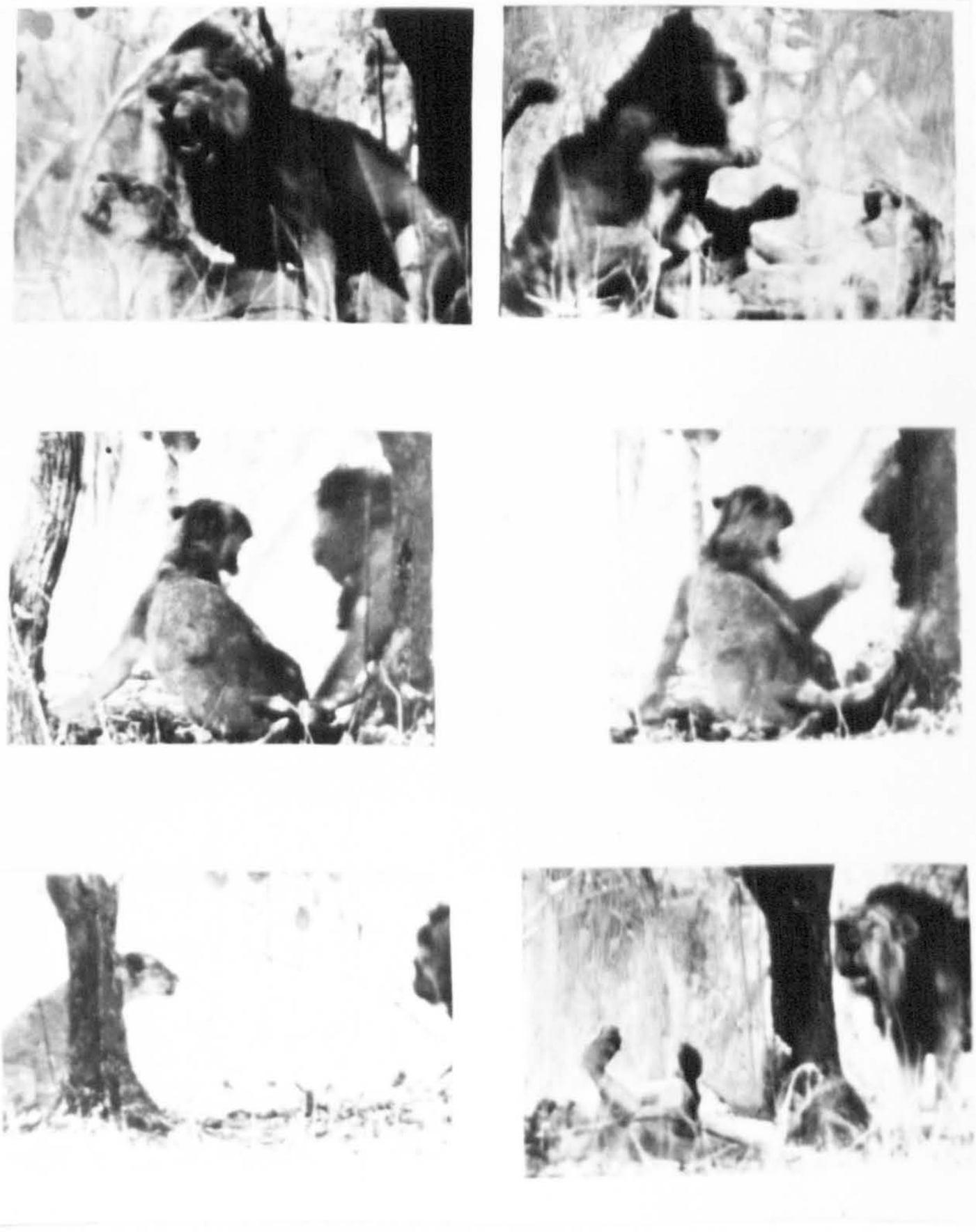


Fig.72: Progression of events after climax

A lioness in estrus may mate more than 100 times. It may be that a large number of matings are required before the female can be fertilized. However it is the experience of some zoo directors that pregnancy can occur when a lion is left with a lioness for only a brief period during estrus.

Ewer (1967) has provided an alternative explanation. She has noted that repeated or extended mating is much commoner among carnivores than it is among herbivores. Actual copulation in some mustelids, for example, may last for several hours, while in most ungulates it lasts for a few seconds. She suggests that the brevity of courting among herbivores is primarily an adaptation to predator pressures, an adaptation which is unimportant to lions, wolves, mustelids, dasyurids, etc., which are themselves the only effective predators in their environments.

Threat

a) Offensive threat: Threat in lions was a complex graded system employing a variety of signals. Ewer (1968) recognized two extremes of threat behaviour in mammals--offensive threat in which intention movements of attack predominate, and defensive threat in which intention move-:ments of withdrawl and retreat predominate.

(i) Simulated head rubbing and parallel walking: At a peaceful level, on rare occasions, lions simulated head rubbing and employed parallel walking as a means of preventing others from acquiring food (fig.73 and 74). Such behaviour was obvious by the recipient's attempts to circumvent the 'aggressor'. In simulated head rubbing. the aggressor directed the dome of its head towards the head of another lion. The eyes were partially closed, the mouth closed and the ears directed forwards. In parallel walking the aggressor walked alongside the other

animal at the same level, so as to shield it from its objective. Both head and body came in contact. If the recipient turned around and tried to approach from the other direction, the aggressor did the same.

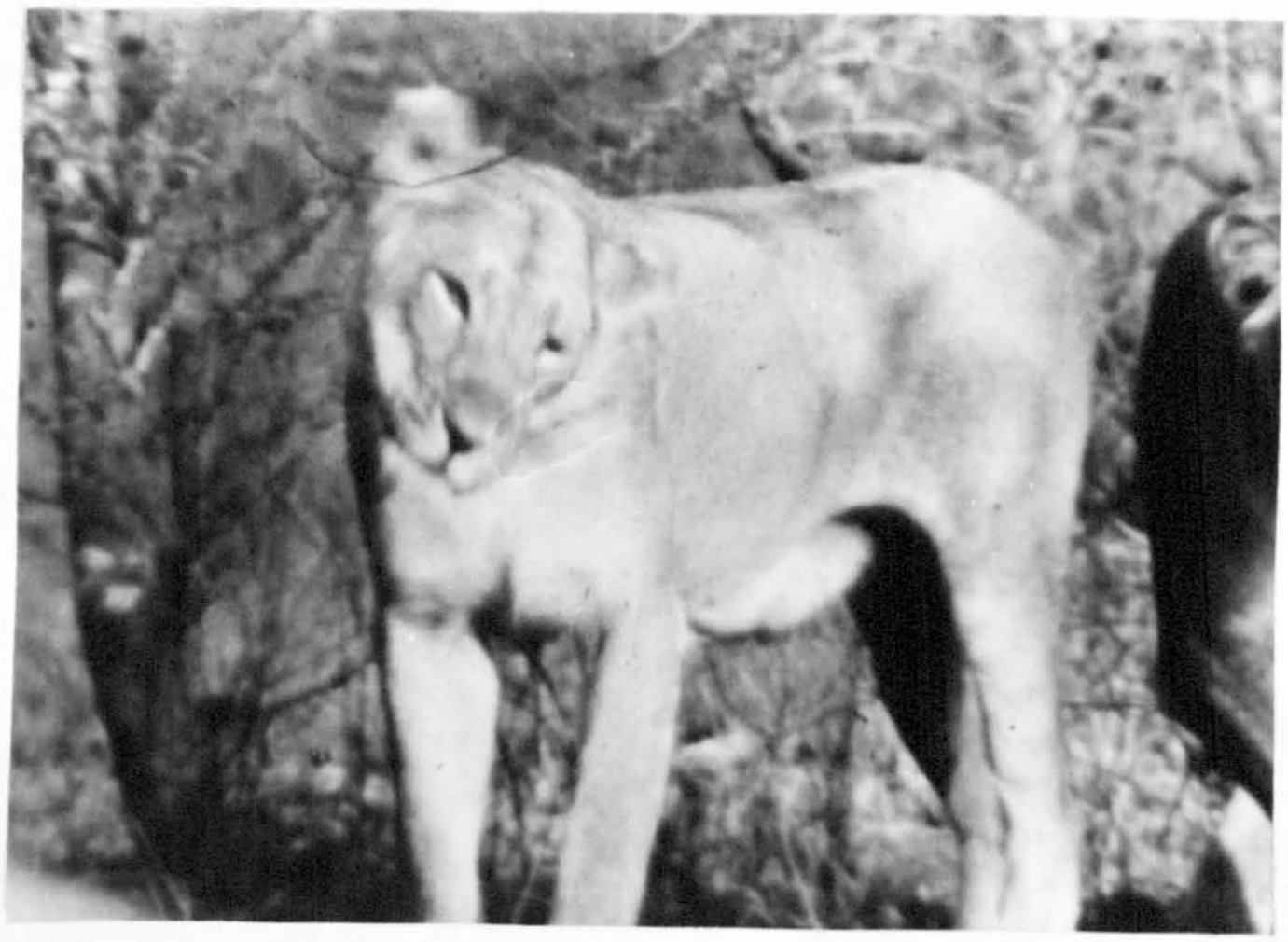


Fig.73: Simulated head rubbing in an attempt to prevent another lion from reaching food

Fig.74: Parallel walking employed by one lion to prevent another from reaching food

(ii) Constricted mouth: According to Leyhausen's (1956) classification of facial expressions among small cats in aggression-fear situations, the most aggressive expression that can be assumed is when the eyes are open, ears forward and mouth slightly pursed with whiskers forward. This expression was observed when lions were about to kill prey and sometimes when threatening humans (fig.75). Growling and flicking the end of the tail from side to side generally accompanied the expression when directed towards humans.

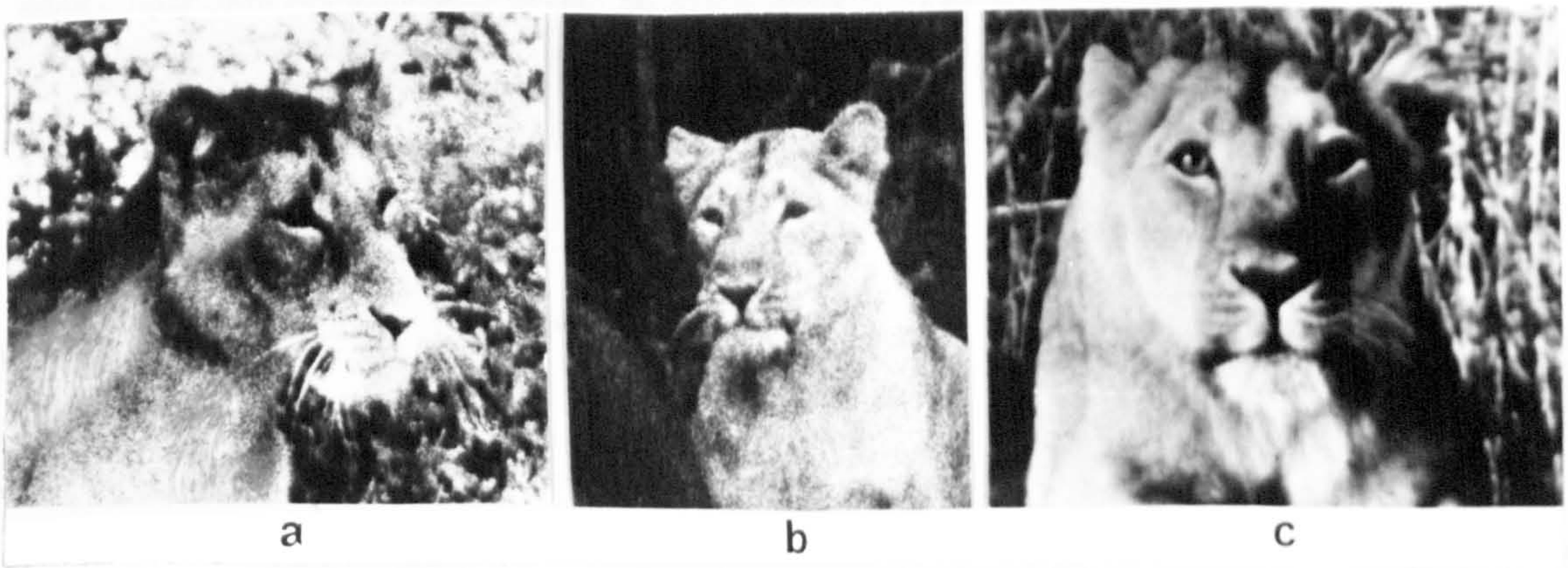



Fig.75: Constricted mouth
a and b -- directed towards buffalo
c -- directed towards man

(iii) Snap: When resting, lions sometimes warned off other lions and humans by snapping (fig.76). The ears were erect and eyes open. The snap was succinct. The average duration of four recorded on cine film was 1.2 sec, the upper canines exposed for 0.4 sec. At that moment the bridge of the nose was wrinkled and the head was thrust forward. Sometimes there was no sound other than the snap

Fig.76: Sequence of events while snapping

of the jaw. At other times the lion simultaneously uttered a loud, sharp call. Sometimes in addition to thrusting the head forward a lion leapt forward 50 cm or more. Figure 77 depicts an instance occupying 1.3 sec, and, as in others, the front legs were spread. Tail slashing across the back often occurred, and usually per-:sisted if the lion was approached no further (fig.78).

Fig.77: Sequence of events during the expression of a snap and a rush

Fig.78: Tail slashing during a demonstration of threat

(iv) Slap: A slap consisted of one lion striking out with one forepaw at another, usually towards its head (fig.79), or at prey, usually at some other part of the body. Slaps between lions usually fell short, and were usually done only once or twice in a conflict. A dispute over food often subsided at this point, sometimes because the recipient gave way and sometimes because the aggressor, though not attacked, ceased to contest any further the opponent's determination to gain access to the food.

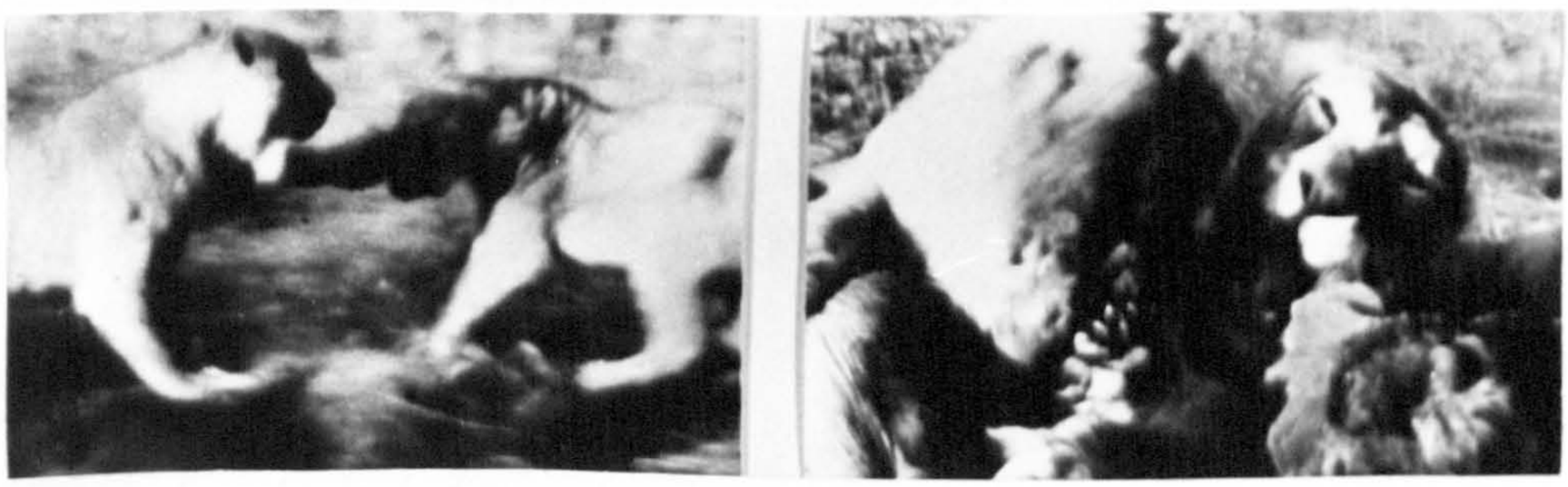


Fig.79: Slapping

(v) Fighting: Lions rarely fought, except for an occasional single slap inflicting minimal wounds. I only twice observed fights sufficiently vicious to result in continual slapping back and forth. They were of 30 sec duration. In one recorded on cine film neither animal actually bit, although their mouths were open nearly the whole time and occasionally pushed into each other. Sometimes the side of one's head was used to suppress the other. It is well known that species equipped with lethal weapons rarely use them in fighting with conspecifics (Eibl-Eibesfeldt, 1970). A lion's teeth are its

most dangerous weapons, but I saw few tooth wounds and many face scratches received from claws. However both Bertram (pers. com.) and Schaller (1972) occasionally observed Serengeti lions biting each other when fighting, sometimes resulting in death.

b) Defensive threat: According to Leyhausen (1960 from Schaller, 1972), defensive threat in cats is characterised by the ears turned back, the eyes closed or nearly so; the teeth displayed in varying degrees with the lips pulled back, and the nose wrinkled.

(i) Extreme open mouth: The most defensive facial expression in small cats is when the mouth is open as wide as possible (Leyhausen 1956). This expression in lions was so momentary that it was only detected in the analysis of cine recordings (fig.80). In addition to the facial expression, the body was drawn rapidly away from the aggressor, the posterior was hunched and the tail curled downwards, but not between the legs. The average duration of the extreme open mouth in 3 observations was

Fig.80: Extreme open mouth

0.25 sec. In each case it occurred when the opponent made a sudden advance. In the first case it did not stop the opponent from slapping the other across the muzzle; in the second, the aggressor thrust its face into the face of the other lion, but did not slap; and in the third, the lion which gave the extreme open mouth was not the intended opponent.

(ii) Defensive open mouth (fig.81): Lions in this attitude had their mouths open, but not to the fullest extent. The eyes were nearly or completely closed, ears directed backwards; the bridge of the nose was wrinkled and the upper lips raised so as to expose both the canines and incisors. The mouth differed from that recorded in

Fig.81: Defensive open mouth

the snap in being kept open for a much longer period. The head was drawn slightly back, rather than thrust forward. The body posture exhibited predominantly withdrawal characteristics. I often saw this behaviour in disputes between lions over food. It was commonly elicited by cubs and young adults when attempting to gain a position on a carcass which was already held by older animals. It

occurred at the moment when older animals reinforced their claim.

(iii) Mouth and eyes closed (fig.82): When compared with Leyhausen's (1956) scale of cat expressions in agress-:ion-fear situations, the defensive closed mouth expression contained both defensive and offensive features. The eyes

Fig.82: Mouth and eyes closed.

were closed, and the ears were directed backwards, both expressions of fear; while the mouth was held closed which Leyhausen equated with aggression. The body posture also varied in the extent to which attack and withdrawal signs were evident.

(iv) Belly-up defensive posture (fig.83): Ewer (1968) described the belly-up defensive posture in the domestic cat as the posture assumed when the animal lies on to its back with teeth bared and striking out with all four paws. According to her, an animal in this state shows no intention of advancing in attack, while at the same time is prepared to defend itself vigorously. I often saw cubs, and sometimes adults, assume this posture when attacked. In one instance two adult lionesses in a

fight lay belly-up simultaneously. What I did not observe was the variation of this behaviour, where the teeth and claws are not at the ready, exposing the throat and belly to the opponent. Ewer (1968) reported that it was the commonest of all appeasement postures among some canids and rodents.

Fig.83: Belly-up defensive posture

(v) Grin (fig.84): Many of the features in this expression were defensive (teeth bared, eyes closed and ears back) but it was used in an offensive context. The

Fig.84: Grin

teeth were exposed by raising the upper lip, and the bridge of the nose was wrinkled. Except for the parting of the lips, the mouth was closed. The body posture was neutral. The grin was used by older more dominant individuals to warn off either cubs or adults which attempted to be amic-:able. In none of the encounters did either cubs or adults persist in their attempts.

This expression appeared not to conform to the Leyhausen scale. However, if interpreted as signalling "I am not intending to attack (eyes closed, ears back), but I am prepared to defend myself by fighting you, if you come closer (teeth bared)", then it would still conform, even though the only 'threat' was an amicable approach.

(vi) Mouthing: A lion making this expression opened and closed its mouth in the direction of another lion. Often one side of the mouth was opened to a greater extent on the side directed towards the lion. While the head was moved in the lion's direction, the jaws were not shut as sharply as when snapping. This expression was seen in much the same context as the grin, and seemed to achieve the same result. Schaller (1972) photographed this expression in the same context.

(vii) Growling: Lion growling (laryngeal rolls) was often heard in encounters with conspecifics or humans but not with prey. Both the face and body were tense. The facial expression was either offensive threat or defensive threat, according to the Leyhausen (1956)

scale of expressions in aggression-fear situations. The frequency and length of each growl and the intensity of sound varied as a conflict built up or subsided. Fewer growls, each approximately 1-1.5 sec in duration and of low intensity were heard at the start of aggressive encounters. As a conflict developed growls, became faster, shorter (approximately 0.5 sec in duration) and the sound more intense. Short growls were often inspirated as well as expirated. Bouts of alternate growling often occurred between lions in conflicts over food, sometimes lasting for several minutes (fig.85).

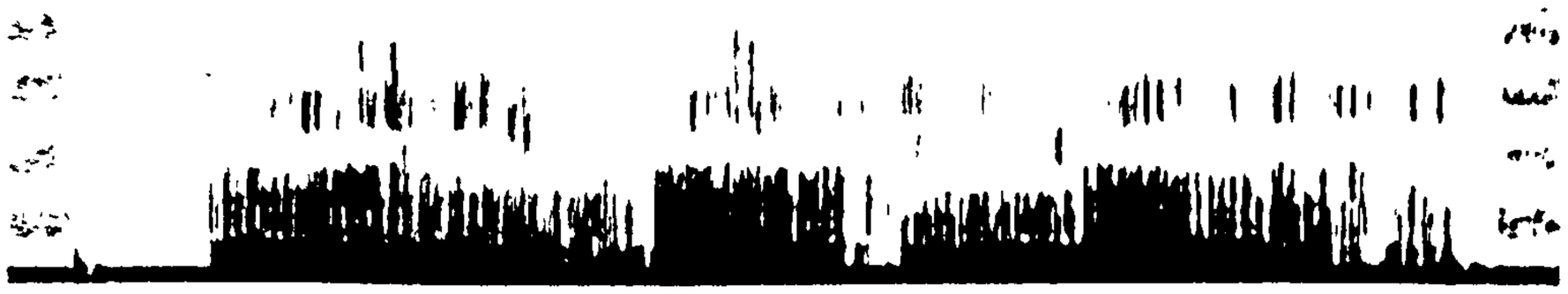



Fig.85: Wide band sonogram of a bout of growling between two lions

(viii) Cacophony (fig.86): Often, when one lion slapped at another, the recipient emitted a harsh, discordant sound. It was commonly heard when a male intimidated a female on first meeting after a period of absence. The call was generally succinct, of c 0.7 sec duration with no change in pitch. The sound energy was concentrated below 1200 cycles/sec over a wide range of frequencies.

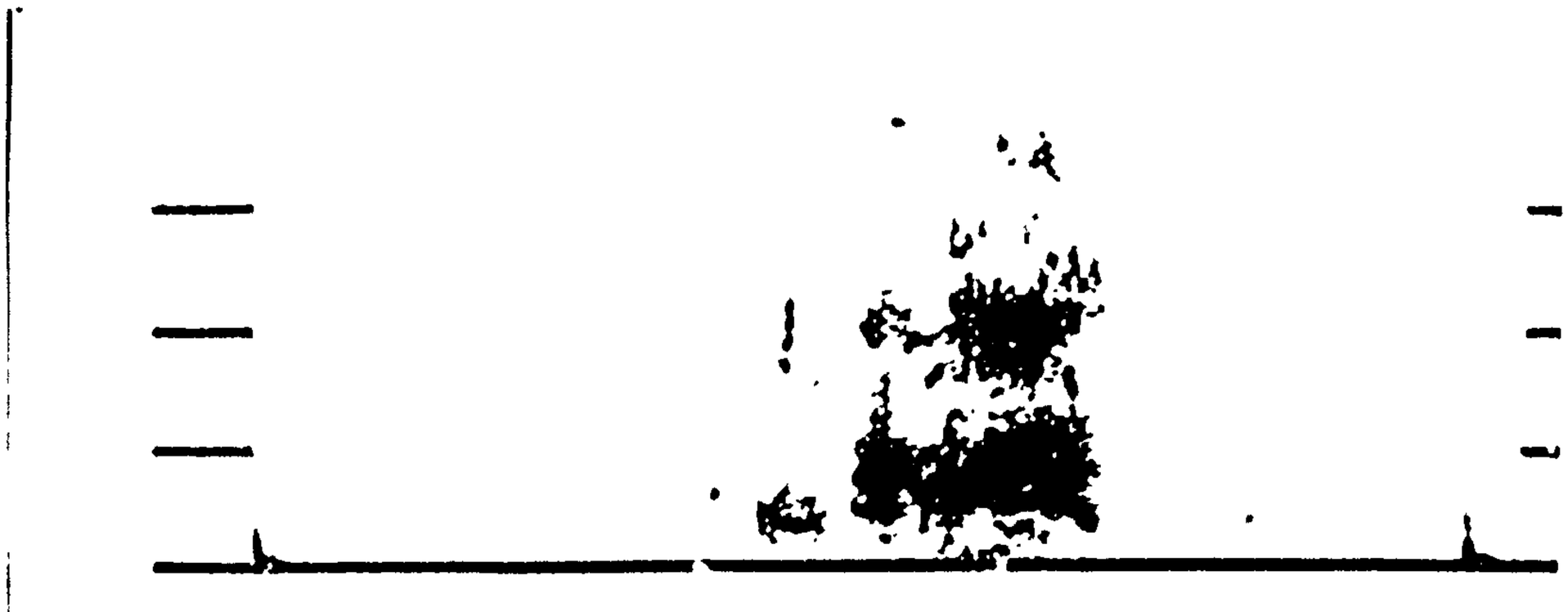


Fig.86: Narrow band sonogram of cacophony

(ix) Voiceless fricative: On a few occasions I heard yearling cubs utter a voiceless nasalized call of less than 1 sec in duration which was both fricative and pharyngeal (M. Joslin, pers. com.) A phonetic description is hhhhhh, and sounded similar to that heard in domestic cats. It was audible only over a distance of 3-4 m, which possibly accounts for why I heard it so seldom. The lions which made the sound simultaneously gave the defensive open mouth. Both Kruuk (1972) and Schaller (1972) described 'hissing' in Serengeti lions which may have been the same type of sound.

c) Situations in which threat behaviour was observed: Threat postures between lions were seen whenever they attempted to feed close together, or a seoond lion attempted to gain a place on a kill which was already in the possession of another. There were some exceptions, including litter mates or companion males that tolerated feeding mouth against mouth.

Threats over food always involved only two individ-:uals. Other lions ignored them unless their own positions became involved. I never saw two lions threaten

or mob a third within the same pride, as has been observed commonly among wolves (Mech, 1970) or hyaenas (Kruuk, 1972). Litter mates commonly fed together, and were more tolerant of each other than of offspring from another litter. Cubs often growled, showed their teeth and sometimes slapped when adults crowded their position. Often their protests were ignored. However one subordin-:ate lioness regularly avoided threatening two eight months old cubs of the most dominant lioness in the same pride. The only time she challenged the cubs over food she growled while holding tightly to the side of a carcass with her chin pressed against it. She did not gain enough confidence to feed for c 5 min, although the cubs largely ignored her and went on feeding. There was no question of her superior physical strength, so that her inferiority was presumably psychological.

Threat behaviour was also seen immediately after mating, before attacks by adult males upon sub-adult males, in range disputes between adult males, in innumerable adult male-female encounters outside courting, occasionally during play, and once observed in a dispute over a lioness between two adult males.

Most encounters between lions and humans involving threat occurred when lions were driven from kills. Usually the lions exhibited some offensive behaviour before retreating, which they always did if approached with a brisk walk, perhaps with a stick in hand. Lions also

threatened humans in other situations. When approached while resting they sometimes growled or occasionally snapped, but frequently gave way without any display. Courting lions generally tolerated an approach to within 50 m, and prior to mating rarely displayed anything more than growling. As mentioned previously, a lioness would often trot a 100 m or so away from people before allowing a male to mount her. During the 30-60 sec after mating when male lions stood or walked around they sometimes threatened people. Lionesses with young cubs, particularly less than one month of age, were often aggressive; growling deterred close approach. Growling by lionesses sometimes helped me to find cubs hidden in dense Carissa thickets.

On rare occasions when lions failed to gain possession of a kill, after conflict with other lions, they behaved belligerently towards man. Individual lions behaved differently towards humans. One lioness tolerated me daily entering a dense ravine where her 1-2 month old cubs were kept. I commonly observed her lying in the lunula position during these operations. If she had been con-:cerned I would have expected her at least to growl and assume a sphinx attitude. Another lioness which normally tolerated an approach to within 3 m, was so aggressively disposed on the birth of her first litter that it was difficult to approach to within 100 m. However she exposed her second litter to the public when 5-6 weeks old, and showed limited concern when approached very close.

d) Other expressions:

(i) Inquisitive face: The first expression of interest in any distant object, including prey and con-specifics, was a raised head with ears cocked, eyes open, mouth closed and noticeable tension in the face. The nose was slightly raised and the lion stared across the end of it in the direction of interest. Other lions often responded by also becoming alert.

(ii) Alert face: Schaller (1972) described the alert face as that when a lion "has its ears cocked, and its eyes are opened more widely than when its face is relaxed; the lips are either closed or slightly parted". This description does not differentiate between the inquisitive face and that which Leyhausen (1956) described as the most aggressive possible. As a result Schaller recorded it in a variety of situations ranging from watching other group members to chasing prey.

(iii) Relaxed face: Schaller (1972) used the term to describe the following: "the features are in a neutral position, with ears erect, and pointing laterally, the mouth closed or hanging slightly open with the lips drooping flaccidly". I observed this expression more than any other in the Asiatic lion, particularly in times of rest. It had no apparent threat value.

(iv) Flehmen: Many mammals show a curious and strikingly similar behavioural pattern in response to certain odours. The following description taken from my

field notes is a typical example of flehmen in lions:

"As the male goes around a tree he crosses the spot where I had seen the female lioness urinate twice this evening. He lowers his head and smells for about 10 sec, then lifts his head above the horizontal, and makes a very distinct flehmen, while waving his head from side to side. His flehmen consists of his tongue sticking out between his front teeth, with the sides curled into a 'U'. The bridge of his nose is frowned, his eyes partially closed. The upper lip is raised, exposing his teeth. He again puts his head down, half crouches on his front feet, and smells the ground for about 15 sec. He then lifts himself up, raises his head upward, and waves it from side to side while making a second flehmen!" (fig.87). In contrast, Schaller (1972) reported that in the Serengeti lion the tongue usually does not protrude past the lips.

The example was the only instance where I knew for certain that a lioness had urinated previously. On another occasion I observed a lioness flehmen after smell-:ing the base of a tree, a likely site for an earlier marking by a male. On a further six occasions courting was in process. These observations might suggest that flehmen has sexual connotations, as has been found among many ungulate species (Buechner et al, 1965; Schaller, 1967; Walther, 1958; and others). However flehmen also occurred under other circumstances. Five of the occasions, exclusive of those associated with courting took place after

a lion had smelled the ground beside a kill. Quite apart from flehmen in lions, on two separate occasions I observed cows make a flehmen a number of times after smelling cows killed by lions (fig.87). Both Schaller (1972) and Ewer (1967) have also observed flehmen in a non-sexual context.

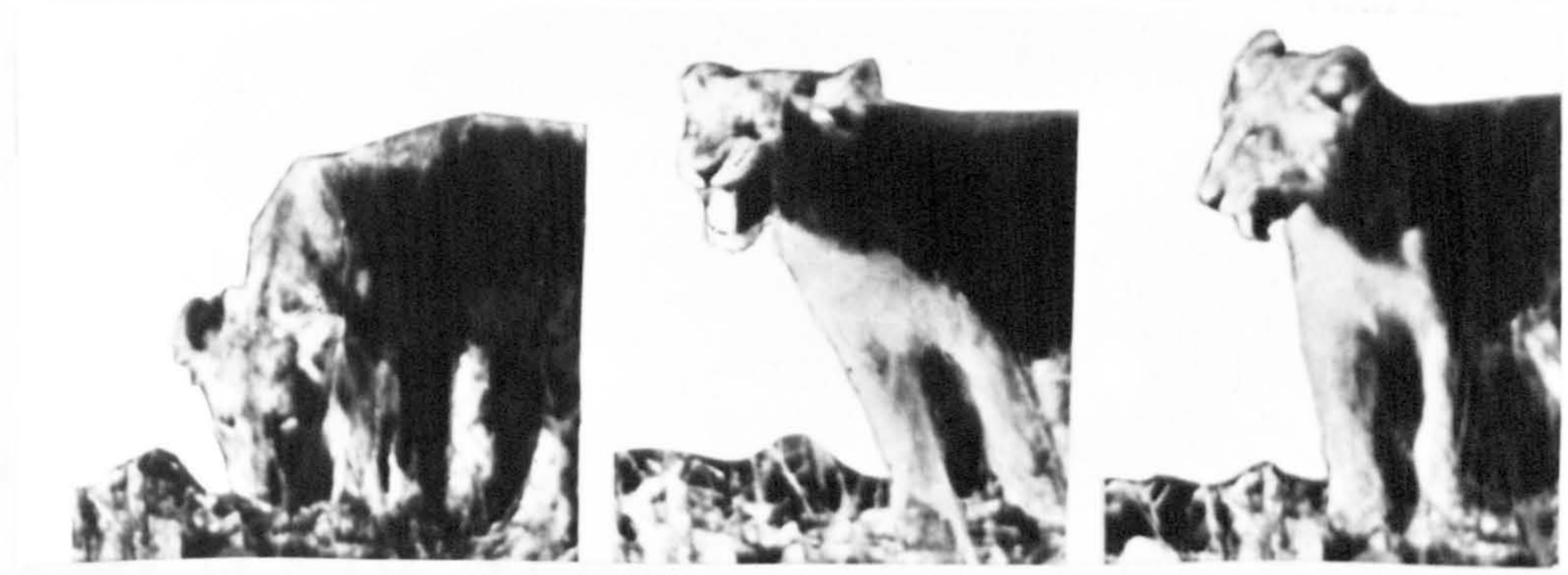


Fig.87: Examples of flehmen, the first by a cub after smelling a site that may possibly have been urinated upon; and the second by a cow after smelling a calf killed by lions

Flehmen was observed on only 17 occasions, 9 of which were by adult males, 4 by adult females and 4 by cubs. The

youngest cub to make it was approximately 6 months of age. The number of times flehmen occurred on any occasion varied from one to five, with two being the most common. With one exception flehmen was made while standing.

ADVERTISEMENT

Introduction: Roaring, spraying, scraping and defaecation were forms of advertisement. The first three were predominantly adult male displays and occurred mainly at night, late evening or early morning when male lions were travelling. When observed by day, advertisements were usually associated with courting.

There was no apparent order in which the advertise-:ments occurred, and they were rarely repeated more than 3-4 times in quick succession. On 89 occasions involving either spraying, scraping or defaecating, 63% occurred one after the other. Roaring either preceded, followed or occurred simultaneously in 36% of the 89 cases.

Advertisement by one lion frequently incited other lions, particularly male companions, to do the same. A male companion roared at the same time as another male in 70% of 73 occasions when roaring was recorded when two males were travelling. A male lion following another male usually lagged behind $\underline{c}$ 50 m, and whenever the leading one marked by spraying or scraping, the second one frequently did the same, usually at the same site.

The differences in advertisement between the sexes was very great. I heard lionesses in 7% of 297 occasions

of roaring, their roars always being weaker and shorter than those of males. Females were observed spraying only 6 times, and were never observed to scrape. However among Serengeti lions Schaller (1972) found remarkable similari-:ties in the form and extent of advertisement among male and female lions. Their roaring was so alike that he had difficulty in recognizing the sex by the sound alone. He recorded scraping and spraying as commonly occurring among both sexes.

Roaring: According to Nice (1941), an auditory cue, to serve in the maintenance of a territory, must be very loud so as to advertise the presence of a territory effec-:tively. When lions roared, their whole sides would heave, sometimes blowing dust from the ground several feet in front of them. At night roaring was usually audible at distances greater than 1.5 km, and on rare occasions as much as 4 km or greater. The area over which lions could be heard in a single roaring session varied from $\leq$ 7-50 $km^2$. Since several roaring sessions were usually made during any one night's travel, the total area over which roaring could be heard was very large. Lions probably could hear roaring at distances equal to or greater than human hearing. Lions at rest sometimes showed interest in something distant, before I became aware that other lions were roaring at a barely audible distance. The duration of roaring by single lions was usually from 20-40 sec. Other carnivores which advertise loudly at night, notably wolves, coyotes and jackels also call for about the same length of time

(Joslin, 1967). I was often able to detect distant lions roaring because of the length of call, and presumably lions could do the same.

Spontaneous roaring was done while standing, walking, lying sphinx or lunula, or while changing from one attitude to another. Roaring in response to, or in conjunction with another lion, occurred in almost any attitude including flat, splayed and upside-down. When roaring, the mouth was partially gaped, but there was no exposure of the upper teeth.

Roaring could be divided into three stages. Initially lions gave one or more low intensity 'soft' roars (fig.88). Schaller (1972) also reported sometimes hearing Serengeti lions give soft roars and follow them with loud roars. Often soft roars were omitted or not heard before full intensity calls. Occasionally lions gave soft roars, but failed to follow them with loud calls. Soft roars could be heard over only 100-200 m, and were difficult to record. They were approximately 0.5 sec in duration, of constant pitch and having a flat profile. More than half of the

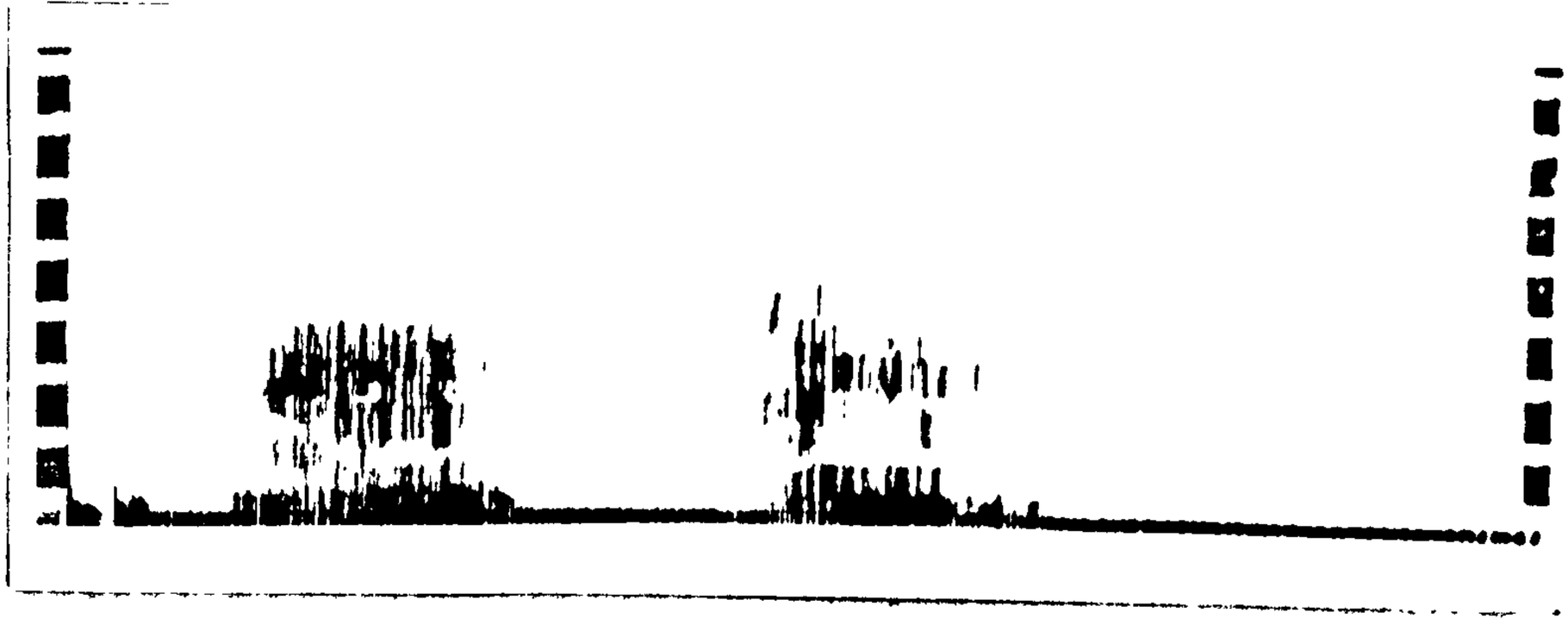


Fig.88: Wide band sonogram of soft roars

sound was concentrated between 750 and 1200 cycles/sec. To the human ear it had a 'gruff' like quality, which was recognizable on the wide band sonogram by the visibly separated vertical striations.

The most familiar aspect of roaring is its series of loud and prolonged calls followed by many shorter calls of lesser intensity and in quick succession. I usually heard 3-7 prolonged roars followed by 15-25 short roars. Occasionally they graded into each other, but more commonly there was a distinct change between the prolonged and short roars. At night both were audible at distances greater than 1.5 km.

The sonogram profile of a prolonged roar was triangu-:lar. The sound was more than one second in duration, and was strongly fricative (fig.89). Most of the sound energy was concentrated below 1500 cps. However in the middle of the call some of the recorded energy occasionally reached as high as 4000 cps. To the human ear these higher frequencies were completely masked by the much stronger lower frequencies. Narrow band sonograms of prolonged roars revealed that the formants were of almost constant frequency, despite the general energy profile (fig.90). The fundamental was between 500-700 cps.

The short roars that followed were strongly expelled glottal fricatives, with partially unvoiced endings (M. Joslin, pers. com.). The sonogram profile was parabolic with most of the energy concentrated below

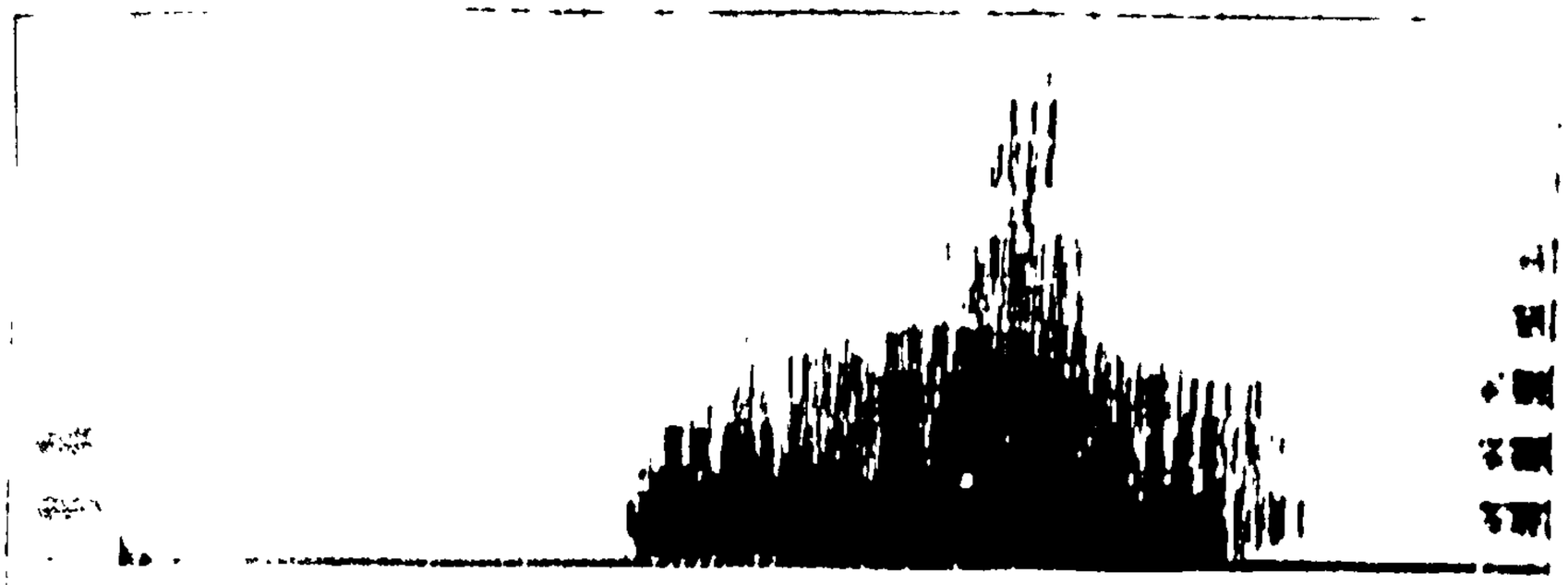


Fig.89: Wide band sonogram of a prolonged roar

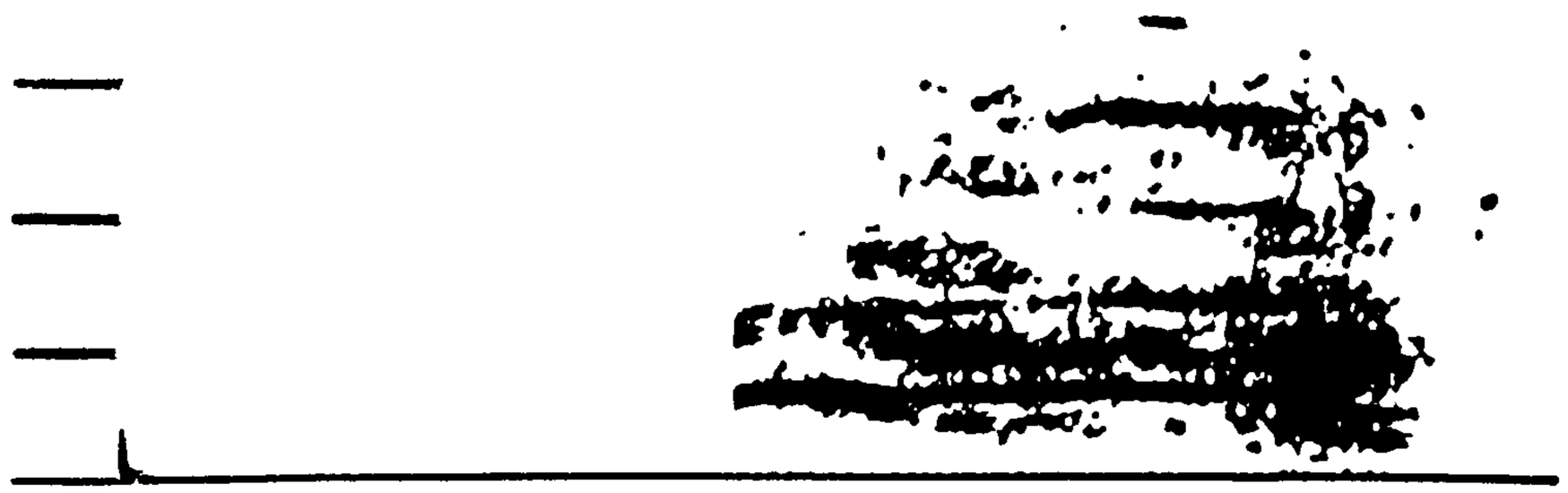


Fig.90: Narrow band sonogram of a prolonged roar

800 cps (fig.91). Each was approximately 0.3 sec in dura-:tion and given at a nearly steady rate of one per 0.7 sec. Schaller (1972) recorded a duration of 0.3 sec for each call with an interval of 0.6-0,7 sec in the Serengeti lion. Occasionally a roaring session ended with one or two calls slightly delayed, so as to be out of phase with the rest.

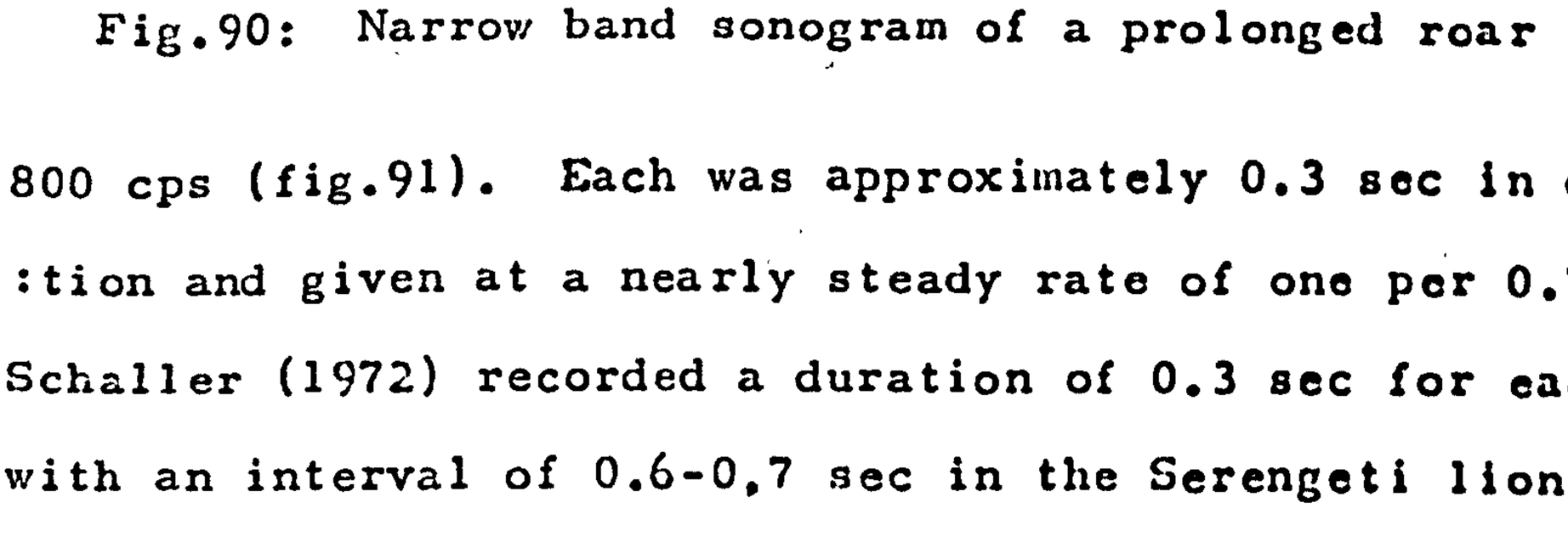


Fig.91: Wide band sonogram of short roars

Spraying (fig.92): Before spraying, a lion would leave a path, walk perhaps 5-10 m to a bush or sapling, usually one in leaf, raise its head and move it about in the vegetation. Schaller (1972) described the subsequent behaviour for the Serengeti lion which adequately covers the Gir lion: "With raised muzzle (it) rubs its face against the vegetation. Its eyes are closed and the motions langorous as if the experience is pleasurable. It swivels around", (customarily at right angles to the line of travel), "sometimes wiggles its rump closer to the bush and with tail raised ejects one to as many as 20 squirts of fluid (with) the caudally directed penis. The fluid consists of urine mixed with scent from the gland located near the base of the tail. It is squirted upward at an angle of 30-40 degrees. The jet may propel 3-4 m, but usually spatters along the leaves".

A lion often turned its head at this point to look at me, which might imply that its act was intended to have some intimidation value for my benefit. I often had the suspicion that this was also part of the intent with roaring and scraping. When I disturbed travelling lions during a rest, they would sometimes spray, scrape or roar.

The description of spraying in the domestic cat given by Ewer (1967) is the same as that in the lion, including the directing of the posterior towards an object which was directly behind.

Fig.92: Stance assumed when spraying. The penis is directed posteriorly and upwards

Scraping: Lions would sometimes move as much as 15-20 m from a path in order to spray on a bush. In contrast, scraping was usually done within 1-2 m. The targets were commonly small bushes, grass tussocks, even dead teak leaves. On a number of occasions I was unaware of any visible directive. While spraying was always preceded by elaborate head brushing against the intended target, head contact was often absent prior to scraping. A brief smell at the ground next to a bush was more usual. Typically a lion would then turn at right angles to the route of travel, lower the posterior into a squat, and urinate in sharp spurts downward and backward. Simultaneously he would scrape the ground 3-20 times with alternate sharp strokes of the back legs, kicking up leaves, sticks and other detritus, sufficient usually to expose some amount of bare ground. Scratch marks were commonly

visible, indicating that the claws had been extended. While scraping, the back legs were noticeably drawn under the mid-line of the body, as compared with the wide apart stance assumed during defaecation. The lion urinated across the inside of its legs and walked on.

Defaecation: Conspicuous sites were not chosen for the dropping of scats. For spraying, a prominent bush was chosen as the site to be marked; in scraping, the object was often small or non-existent, but was always supplemented with scratching, making it clearly visible, even to man. Scats were visible without marking. Lindeman (1955 from Ewer 1967) noted that the European lynx (Lynx lynx) and wild cat (Felis silvestris) deposited their faeces in obvious and salient places along their territorial boundaries. I did not observe this in lions. However that lions recognised scats as 'sign' was suggested by their occasional leaving of new scats beside old.

Lions often defaecated near places where they fed but generally moved to the edge of the clearing. Similarly Schaller (1972) noted that resting Serengeti lions tended to move to the periphery of the group before defaecating. Miss Brewster and I observed at feeding sites that nearly all soft scats, and many of the more solid ones were consumed by crows and Egyptian vultures within a day. Those scats which lions deposited furthest from feeding sites were often not eaten, and thus remained as potential advertisements.

PREY CATCHING

Most data on prey catching and feeding behaviour came from watching tethered buffalo being killed and eaten, examining carcasses of farmer's stock lost to lions, and interviewing farmers. Three stages of approach were studied: stalking, precontact and contact.

Stalking: Unlike older and more experienced lions, sub-adults and lions new to taking tethered prey sometimes stalked in a full crouch and took advantage of cover (fig.93). The full crouch gave the smallest frontal view of any posture. Occasionally lions used tree trunks as cover, sometimes lying with one paw on either side.

Fig.93: Full crouch

Leopards stalked more frequently than lions. A number of goat offerings were made by the Forest Department in its regular 'leopard show'. For months the two leopards involved were habituated to nightly offerings at the same site and to people viewing from the same place which was always approached from the same side. Yet the leopards

remained infinitely more cautious than were less habituated lions in day time 'lion shows'. Leopards sometimes spent a half hour or more stalking, although their prey was tethered. When cover was available, it was used, even twigs c one cm diameter. On a number of occasions when I observed them along roadsides at night, they even angled over to the shadow of a tree cast by my spotlight and walked away along the shadow. I never observed lions behave similarly.

Usually lions, in 'lion shows' when offered buffalo, rose and walked towards it within a minute or two after the captive prey was left unattended. The first few steps were sometimes slow or 'frozen' in various positions. Sometimes lions approached buffalo with it facing them, but at other times they waited until it was facing away before rising. Occasionally, when game keepers wanted to hasten an attack they would position a buffalo so that its posterior faced the lions, or they would walk behind the lions and force them to stand. Once standing, lions almost always attacked the prey. Usually they walked to within 20-30 m before breaking into a trot. On rare occasions they galloped, sometimes as much as 100 m. It was my impression that if a buffalo attempted to flee, this precipitated a rush.

Pre-contact: When the prey was reached, but not yet touched, some form of momentary stance which resembled sitting was usually assumed. It gave a power base for

springing, with the weight mainly on the back legs, while at the same time giving the lion an opportunity to judge the situation before proceeding (or retreating). Undoubt-:edly tethering of prey had much to do with precipitating this stance. Figure 94 shows examples of pre-contact, but are atypical in so far as two of the lions are facing the buffalo head on. Only small buffalo were ever tackled from the front, and then rarely and by very experienced adults. Normally if a buffalo lunged at a lion, the latter jumped back and circled around until an opportunity arose to attack from the rear. When attacking tethered prey, lions commonly fixed their stare upon parts of the body other than the head, such as the high point of the back or withers. This was in marked contrast with their behaviour when contesting other lions or humans. When two or more lions took part, the prey was at a major dis-:advantage, and no matter how large, it could always be brought down after an unguarded attack at the rear while attempting to ward off a lion at the front.

Fig.94: Pre-contact

Contact: I observed that goats were either bitten over the middle of the back (fig.95a), and an attempt made to carry them away, or they were bitten in the neck. Both methods were corroborated with farmers' evidence. Experienced lions sometimes simultaneously immobilised and killed buffaloes less than about 8 months old by attacking the neck (fig.95b) but larger prey was brought down before killing. Lions occasionally lept onto the back, but usually they grasped the prey and bit it while keeping their hind legs firmly on the ground, using them as support in levering prey off balance (fig. 95c, d and e). This method of tackling prey was unlikely to have been adopted because prey were tethered. Innumerable 'natural' kills of bovid stock were also bitten over the back, and clawed on the sides in the same manner. Schaller (1972) described the same behaviour in the Serengeti lion.

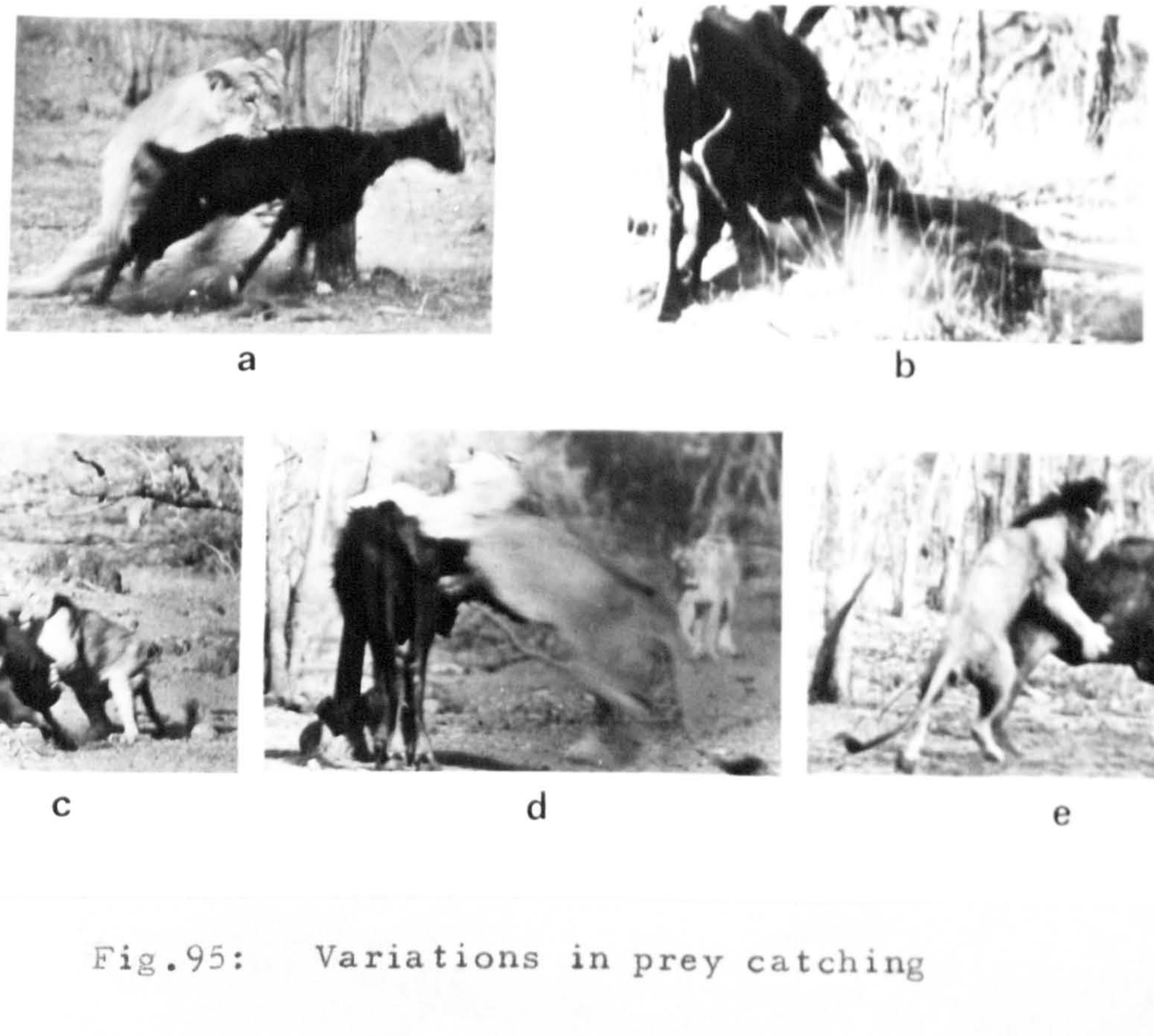



Fig.95: Variations in prey catching

Neck bite: Lions usually killed prey by biting the neck just below the head (fig.96). Of 114 natural kills investigated, 106 (93%) were bitten at the neck. Fifty-nine per cent were ventral neck bites, 16% dorsal and the remaining 18% were undifferentiated. The location of neck bites varied according to the size of prey. Ninety-three per cent of adult bovids and 54% of young bovids were bitten ventrally in 85 instances of neck bites among natural kills differentiated between a dorsal or ventral bite. This difference was significant ($X^2 = 15.76$; d.f. = 1; $p < 0.01$). The same pattern was observed when lions killed tethered prey. The results were partly attributable to adult buffalo always being toppled on to their back usually exposing the ventral side of the neck when bitten, whereas young buffalo were often not knocked down before being bitten. However there were a few cases when lions deliberately bit the throat when it was directed away.

Fig.96: Neck bite

Only one lion at a time gave the neck bite in all but one of c 50 observations. On some occasions, if prey began to thrash about after a neck bite had been released the same or another lion repeated the bite. It was often maintained for several minutes, even when the prey had been killed instantly. Most kills showed little or no loss of blood.

The characteristics of a ventral neck bite include:

a) the advantage of keeping the prey on its back and therefore helpless and unable to flee.

b) the possibility of destroying any one of three vital systems. Most commonly trachrae were damaged (fig.97), occasionally the cervical vertebrae of even adult bovids were crushed and occasionally the jugular veins were injured.

If prey was not killed instantly by the destruction of the central nervous system, then it died either because of the interruption of blood flow to and from the head , or because of strangulation. Prey usually had great difficulty with breathing, indicating strangulation as the most common cause of death as was also found in the Serengeti by Schaller (1972).

Discussion: Adult lions were often extremely proficient at killing, occasionally killing their prey almost instantly. The neck bite was used only for killing, the actions involved were different from those involved in capturing and devouring prey. In this respect lions are

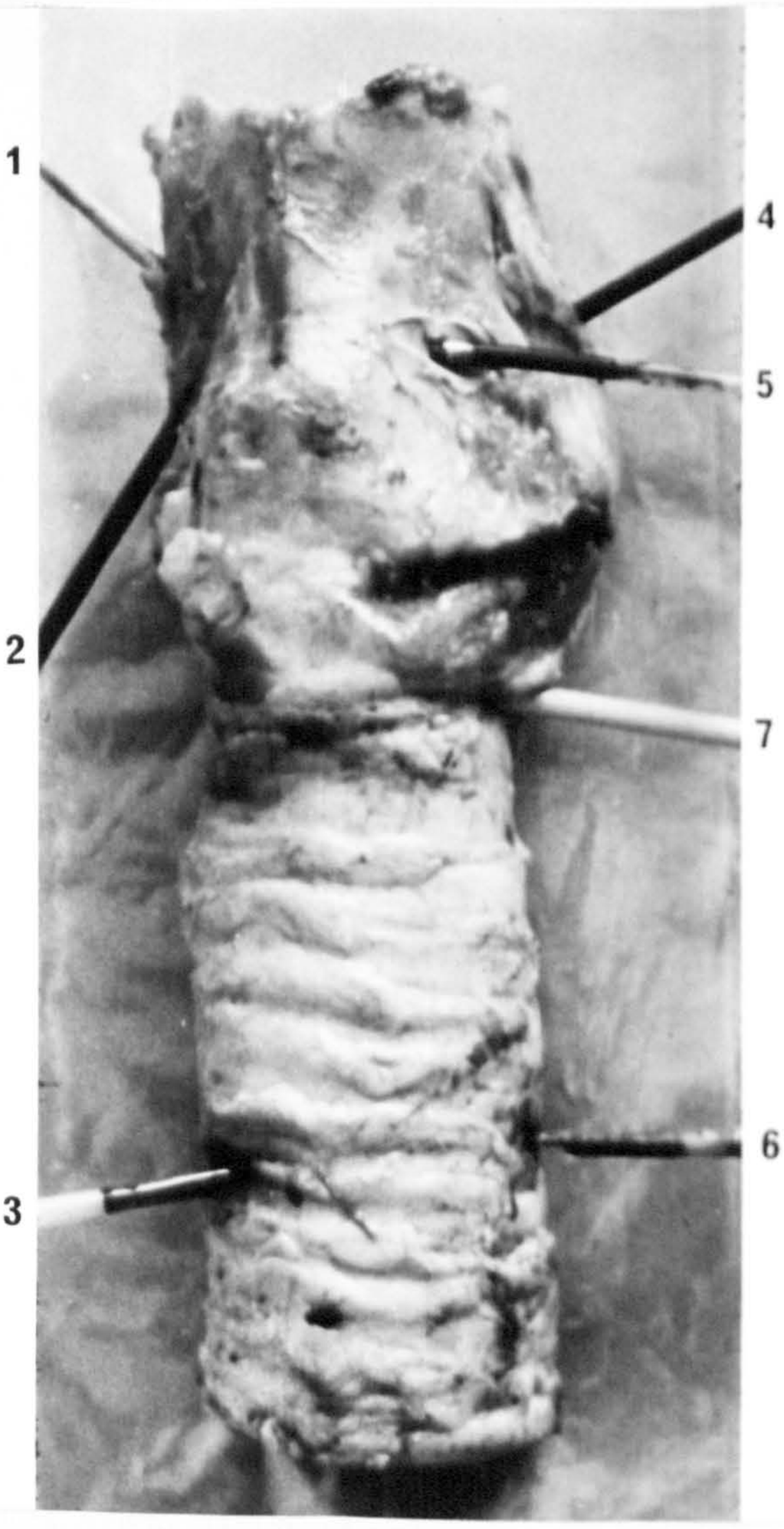



Fig. 97: Trachea and larynx of adult female buffalo killed by lions. Pointers 1-6 indicate places where teeth penetrated. Trachea also slightly dislocated from larynx (7)

similar to other cats (Leyhausen, pers. com.), but different from wolves (Mech, 1970), African hunting dogs (Estes et al, 1967) or hyaenas (Krunk, 1972). Leyhausen found the neck bite stereotyped in domestic cats, and ooncluded that biting a constricted part of the body was innate. Flynn (pers. com.) has been able to artificially elicit neck biting in domestic cats by stimulating certain areas within the hypothalamus and mid brain. However Eloff (1964) reported that Kalahari lions killed gemsbok by breaking their backs. Schaller (1972) observed that Serengeti lions sometimes killed wildebeest by biting across the muzzle. Their observations suggest that in lions much of the method of killing, including the location of the bite, is probably learned. Cubs and sub-adult lions which I observed frequently bit at the wrong place, often released too soon, and sometimes tried to feed without first killing the prey. Occasionally adults fed without killing in the normal way, and as already described, the methods used in killing large and small prey was often different. I also observed leopards killing adult and young goats in different ways. Adult goats were commonly bitten across the neck, just below the head, often damaging the posterior processes of the lower jaw. Young goats were sometimes bitten through the skull.

Lions usually held the neck bite for several minutes and because of this, gamekeepers thought that lions sucked blood -- an explanation accepted by Von Ullrich (1962)

after watching four kills. However the lions and leopards that I observed bit their prey so firmly that it would have been extremely difficult to suck; moreover, most kills showed little or no blood loss. After weaning, lions were only observed to drink by lapping. The probable explanation for the protracted kill bite was to ensure that the prey was rendered immobile, death by strangulation taking several minutes. However, occasionally when prey had been killed instantly, lions continued to hold the neck bite for some time, possibly because lions are unable to recognise an animal's immobility, unless sustained.

Van Lawick Goodall (1970), Kruuk (1972) and Schaller (1973) have remarked on the efficiency with which some large predators are able to kill prey. However neither their observations nor my own indicate that predators are capable of recognising suffering; death being merely a by product of rendering prey immobile and harmless. I often observed lions feeding when prey had only been immobilised, but not killed. In rare instances buffalo recovered sufficiently to bawl and struggle for 30 min or more before eventually succumbing to trauma caused by feeding. The present system of tethering prey encourages a prolongation of death and frequently allows cubs to attempt a kill before they are old enough to do so properly.

FEEDING

Entry: Before starting to feed, lions usually licked the site for reasons which remained unexplained. Not surprisingly, licking often resulted in getting hair into the mouth, which was immediately rejected. Goats have long, dense coats, and before feeding on them, lions sometimes removed some of the hair with their incisors, ejecting it to one side by scraping it off the tongue against the upper incisors. The pattern was repeated a few times. Leyhausen (pers. com.) observed the same behaviour among tigers and many species of small cats.

Usually the region between the back legs or over the anal region was eaten first, but if several lions fed simultaneously, additional 'points of entry' were chosen, such as between the front legs. Cubs sometimes bit an extremity, such as an ear or nose. Entry over the fleshy abdomen was not difficult, but entry over the anal region involved chewing through bone. Lions made little use of their front feet as an aid to feeding, so differing from the act of killing, when the front paws were used to grasp, and in some instances to squeeze the neck in an arc.

Group structure when feeding: Numbers of lions feeding at kills varied considerably and were often correlated with the size of prey. When prey was large, such as an adult buffalo, two or more often fed together. However when prey was small, e.g. buffalo calves 1-2 years old, only one lion usually fed at a time, although there

was room for more, so contrasting with African hunting dogs (Estes et al, 1967), wolves (Mech. 1970) and Spotted hyaenas (Kruuk, 1972), which feed communally however small the prey. Mech (1970) observed wolves feeding on moose in such densities that there was physically no more room for others to participate; Kruuk (1972) observed similar behaviour among hyaenas. With lions the situation was different. Often they lay within 50 m of a carcass, apparently disinterested, perhaps even rolling around on their backs, or facing away but as soon as the feeding lion moved away another quickly took its place (fig.98).

Fig.98: Two sub-adult lions waiting for a lioness to cease feeding and leave, so that they may start.

In addition to being governed by the size of prey, the numbers of lions that fed simultaneously were also influenced by their maturity and affinity. Cubs of all ages fed together more frequently than adults. Cubs of the same litter often ate together, sometimes virtually mouth to mouth, while cubs from different litters were much

less tolerant of each other. Adult pairs with close affinities, such as amicable males which travelled, rested, advertised and hunted together, sometimes fed together but I rarely saw adult males feed with adult females, and then only on adult buffalo, where they could keep well apart from each other. When young cubs were feeding, adults sometimes came along and ate, paying little attention to protests from cubs. On the otherhand, when adults were feeding, cubs often tried to do the same, but usually approached in a submissive attitude and with prolonged caution.

Parts consumed: Lions ate variable amounts before leaving their prey. On rare occasions adult males killed but did not eat, or delayed feeding for an hour or two. Often, when only one or two lions were present, the flesh was consumed around the pelvic girdle and partially down the upper most back leg, the internal organs were eaten, as were the mesenteries attached to the rumen, but the large intestine and rumen wall were rejected. The rumen was often dislodged or pulled entirely free to permit access to the internal organs. Scott (1968) has shown that the Felidae are incapable of manufacturing their own vitamin A, and need liver, if not lungs, adrenals and kidneys, if they are to obtain their Vitamin A requirement. Lions also ate some hide, even when plenty of flesh was available. Eating hide was as difficult as chewing bone, and could only be done by using the back of the jaws over

a long time. Similarly they often ate extensive portions of the femur, when it would have been much easier for them to consume more flesh. Presumably they selected hide and bone for specific nutrient requirements, such as calcium.

Lions sometimes ate the intestine. They used their tongue to draw a portion across their upper incisors so that the contents were prevented from entering the mouth (fig.99). The side of the jaw was used to cut off sections c 20-30 cm in length before swallowing, repeating the process several times.

When several lions were present and the prey was a buffalo calf feeding was extensive. Almost everything that could be eaten was, including the intestine, wall of the rumen, most of the hide including around the skull, most of the rib cage and vertebral column, parts of the leg bones and pelvic girdle, and occasionally the back of the skull and brain.

Lions usually fed more than once in the course of a night, resting for perhaps several hours between feeds. They usually rested c 100 m distant, or substantially beyond where other lions usually lay when waiting for a

Fig.99: Lions ingesting tubular structures while rejecting their contents.

turn to feed. Lions resting after a feeding bout, commonly lay flat and appeared to sleep.

Carcass removal: Lions seldom carried anything from a kill site, except the intact kill, unless feeding was so extensive that the prey was reduced to pieces. Intact carcasses were dragged anything up to 1000 m, while pieces were rarely carried more than a few meters. More than half of 120 naturally killed domestic bovids were dragged, largely in response to disturbance from herdsmen and villagers (see p. 93 ). Lions sometimes attempted to remove tethered prey when people were too close, but usually not until after the neck bite was completed. Lions chose a variety of locations to bite in order to obtain a grip for dragging, such as the shoulder, neck, lower back, etc. When carcasses were tethered, lions sometimes tried several times until physically exhausted. On other occasions they tried only once or twice, and then began feeding. The strength employed in pulling was so great that on one occasion an adult male lion succeeded in ripping a tethered calf in half. Lions never investigated the rope which tethered prey, no matter how obvious it was, although they could easily have severed it.

Untethered prey as large as sub-adult bovids or occasionally adult cows were dragged by straddling with the front legs and walking forwards, supporting much of the weight with the lion's teeth. Larger bovids were dragged backwards, and usually for only a few meters. On some

occasions lions dragged adult bovids weighing several hundred kilograms.

In the morning lions frequently dragged (or attempted to drag) carcasses into cover before resting near by. It was sometimes induced by the presence of crows or vultures. On one occasion a lion returned to a kill when it saw a vulture fly in the direction of a carcass. The lion dragged the carcass c 300 m into dense cover, then lay near it.

DRINKING

When drinking, lions commonly crouched on their front feet, while lying on their back feet (fig.100), however other postures were sometimes observed, such as standing on their back legs while crouching over their front feet, or lying in the sphinx posture with the front paws extended or folded.

Fig.100: Most commonly observed drinking posture.

Like other felids, lions drink by lapping, an inefficient method of water intake. Each lap took c 0.7 sec, and ingested little more than the water which momentarily clung to the thorny distal end of the tongue. As a direct

result, lions usually drank from 4-8 min, in contrast to the average drinking time of 15 sec for four buffalo.

Measurements were maintained on the water intake of a lactating lioness for three weeks. A calibrated tub of water was provided within 10 meters of where the lioness's few week old cubs were in hiding, and was checked once daily. Sand placed round the tub provided a suitable substratum for determining whether the tub had been visited by the lioness on the basis of presence or absence of her tracks. A source of water 300 m distant was stopped, and the nearest other alternative was c 2 km distant. Assuming she drank only the water provided, she averaged c 1.5 litres per day, and drank on most days.

It was my impression that non-lactating lions drank about once every two days when near water, but they were able to go without water for much longer periods. One courting pair, observed continuously for five days, did not drink until mating ended on the fifth day, although they were within a hundred meters of water at various times during the courting period. Schaller (1972) observed Serengeti lions going occasionally for 4-5 days without water. Eloff (pers. com.) followed the tracks of many lions over several days in the Kalahari desert, and concluded that some lions replenished their water needs only from the fluid content of their prey.

# CHAPTER 13

# CONCLUSIONS AND RECOMMENDATIONS

This research examines the ecology and behaviour of the lion leading to recommendations for its conservation. This chapter summarises some of the more important points.

## OUTSIDE THE SANCTUARY

Although lions recently existed in large numbers outside the Gir sanctuary, the conditions there are now so poor that survival of lions is difficult or impossible. They are now rarely seen outside the boundaries, and then usually within 1-2 km, suggesting that they are only transients from the sanctuary.

The changes in the lion's environment are due to man. The human population of Junagadh District, which encompasses most of the area, has increased from 4.7 per $km^2$ in 1901 (Edwards *et al*; 1907) to 11.7 per $km^2$ in 1961 (Anon, 1967a) while the forest cover has decreased outside the sanctuary by *c* 87% between 1872 and 1969. About 69% of the land which I surveyed was cultivated, harbouring few prey, and a further 17% had no cover, so that lions could not attack livestock in day time without being seen by herdsmen. Wild ungulates had become so rare as to be insignificant as prey. At night, almost all stock were corralled behind stone fences inside large villages, making the prospects for prey catching even more arduous. Hide collectors were also numerous, and they took 77% of the domestic animals which lions killed. Mainly because of these unfavourable conditions, only 16% of the livestock losses which I examined were found outside the sanctuary, and lions ate nothing from

40% of these. Moreover there is little that one can recommend which would stabilise conditions, since further land development would seem to be inevitable. For these reasons conservation within the sanctuary is vital.

INSIDE THE SANCTUARY

Conditions here were much better, but there is cause for concern. Although less than 6% of the area was cultivated, more land was being cleared. Most cultivated lands encroaching upon the boundary were associated with forest settlement villages, which have themselves developed largely since the turn of the century.

In the dry season c 49,900 ungulates used the sanctuary daily. These stock consisted of c 5600 (11%) wild ungulates, 20,000 (40%) resident domestic stock, 5600 (11%) domestic bovids belonging to forest settlement villages, and 18,700 (37%) transient domestic bovids kept outside the sanctuary at night. The prey consisted of 53% buffalo, 30% cow, 5% oxen, 8% chital and 3% other wild and domestic species.

Analysis of 460 lion faeces collected within the sanctuary showed that at least 75% of the lion's diet was domestic stock. In a sample of 350 domestic animals which lions attacked 40% were cows, 41% buffalo, 13% oxen and 5% consisted of combined totals of camel, sheep, goat, horse and dog. Lions showed a strong preference for cows over buffalo when compared with the abundance of each in the population. The preference for cows was probably because buffalo were often aggressive towards lions, while cows

were not; and because grazing buffalo were more favourably placed within the herd to receive protection from herdsmen. Sanctuary herdsmen offset their high losses of cows by purchasing reproductively mature replacements. The reason they keep cows at all is mainly to sell the oxen which are born. The herdsmen also do not have to pay an annual fee for grazing cows inside the sanctuary, as they do for buffalo.

The lions are required to kill far more than they need because feeding is prevented. Feeding was poorest at night, when lions made kills within villages and were driven off before they had eaten. They ate nothing from 41% of domestic animals killed at night. Much of this loss of food would be reduced, and fewer stock lost as a result, if herdsmen made kills available to lions by moving carcasses to the outside of villages immediately following an attack. Payments are made by the Gujarat government to herdsmen whose bovid stock has been killed, and could be made to favour those who remove lion kills from villages immediately following an attack.

Sixty-one percent of attacks upon domestic stock occurred in day time, mostly in mid morning and mid afternoon. These peaks were a compromise between lion activity, which was lowest through the middle of the day, and the abundance of grazing prey, which built up in the morning, then decreased in the afternoon. In day time, lions were usually able to eat something, but also lost substantial amounts,

mainly due to hide collectors who scavenged what the lions caught. If hide collectors did not take the meat, then they made it so accessible to vultures as to make further use by lions impossible. More than half of kills investi-:gated within the sanctuary were ultimately claimed by hide collectors, most of whom had come from outside. Herdsmen could be discouraged from reporting their losses to hide collectors by making this one of the conditions for obtain-:ing compensation from the government. However c 20-25% of 100 hides in the possession of hide collectors were found to be those of lion kills, representing a significant part of the hide collector's livelihood. Any programme that might be instigated to prevent hide collectors from appropriating kills would have to take this into account, preferably with a better form of livelihood.

If the system of paying herdsmen whose stock has been killed is to be used as a vehicle for improving the lion's food supply, then it would have to be greatly improved. When I asked herdsmen who lost stock whether they intended to request assistance, only 49% said yes, and fewer actually did. Of the estimated several thousand livestock killed between 1969 and 1971, only 430 applications for payment were made of which 25% were rejected. Few herdsmen under-:stood the conditions for eligibility, all had to wait months for payment, and when it was not forthcoming they were rarely told why. Owning more than 20 head of stock, or having an animal killed by lions more than two furlongs

(c 400 m) from a herdsman's village constituted reasons for ineligibility. (At the time of writing the second condition has reportedly been stopped (Tolia, pers. com.)).

## REMOVAL OF DOMESTIC STOCK

There have been many recommendations to remove the domestic bovids from the sanctuary, and so allow lions to find a 'natural' and sustainable balance by surviving on the wild ungulates. At the time of writing such a programme is being put into action. However, this scheme must be viewed with caution. These lions depend on domestic bovids for most of their food, and there is no evidence to indicate that the situation in Gir has ever been any different. Cattle evolved in Asia, and the earliest descriptions of Gir refer to cattle being there in large numbers. Berwick (unpublished report) has recently established that domestic bovids and wild ungulates occupy largely separate feeding niches in Gir and do not compete. In addition, if cattle were removed suddenly, lions might starve and decline in numbers, as well as have a disastrous effect on the population of wild ungulates.

While a sudden and total exclusion of domestic livestock should not be advocated, a gradual and partial removal might be desirable. It is obvious, even to the casual visitor, that the sanctuary is being severely overgrazed. Although teak is an indigenous species dominant in most areas, there is no natural regeneration because of damage by livestock. All growth of new teak which occurs at present is achieved

by banning cattle and buffalo from areas of coppicing and early plantation growth. Hodd (1970) has shown that in the areas of grazing by domestic bovids 70% of the soil is exposed to erosion by rain in the monsoon because of loss of ground cover. Heavy trampling by livestock further compacts the soil, increasing runoff and making seedling establishment less likely. He predicted that the long-term effect of over grazing would be to completely change the soil structure and composition, presumably for the worse. Talbot (1959) predicted that at the present rate of attrition through overgrazing, the Gir forest would only last 20 years, which, although a much gloomier forecast than the situation really was, does stress the need for concern. Some of the land abuse probably stems from the fact that buffalo and cattle are fed imported food supplements, and so are not kept in check by the resource limitations of the sanctuary alone. Herdsmen interviewed in 50 villages reported feeding a daily average of 3.8 kg of cotton seed and ground nut to each adult buffalo and smaller amounts to cow and oxen, or an estimated 19 million kg fed to all domestic bovids within the sanctuary each year.

The effects of a limited reduction in numbers of domestic stock on the lion population should be studied. Phased over a long time it will likely improve the stability of the Gir ecosystem, and presumably create conditions more suitable for sustaining lion numbers.

## POPULATION TREND

Evidence that lion numbers have declined recently inside the sanctuary is inconclusive. Trend determinations in the past have been based on comparing the estimated absolute size of the lion population with that of previous estimates, each of which have been ascertained from track measurements, involving some major and untested assumptions as well as much personal interpretation. Dalvi (1969) attempted to improve the accuracy of estimating lion numbers by using three methods. I made five estimates averaging 190 lions, and ranging between 100-250. While such determinations roughly indicate the population magnitude, they are not very reliable. A more sensitive indicator of population trend could be assessed using several indices of lion abundance which are simpler to determine, easier to repeat, involve fewer assumptions and are not dependent upon knowledge of the actual population size. I established data on three indices against which future changes can be assessed; namely the average number of lion kills occurring among sanctuary villages per year, the average number of km of road surveyed for each lion scat found, and the average number of km surveyed for each km of road recorded in which lion tracks occurred.

## LION MORTALITY

Estimated mortality was found to be high among young lions, and low among adults. Because adult lions are able to kill proficiently, loss of a few kills probably matters

little. However cubs are entirely dependent upon lionesses for food, and moreover, greatly restrict the area over which lionesses can hunt. If food is limiting the size of the lion population, as the distribution of lions, lost prey and uneaten carcasses implies, then an abnormally high cub mortality is what could be expected.

BEHAVIOUR

There were important behavioural differences between adult males and females. Male lions moved more than females both spacially and temporally. Male lions made extensive use of advertisements, such as roaring, spraying and scraping, whereas females made very little. Male lions often associated with a second male, but with rare exceptions attacked other males, whereas females often associated with several other females. Both males and females frequented regularly a few parts of the range, but usually not at the same time. I saw fewer adult males than adult females, and very few young males 2-3 years old. Adult males were sometimes seen challenging young males within prides, and may have encouraged young males to leave prides before they were able to kill with the frequency and proficiency required for survival.

Group structure within the pride was flexible, and varied almost daily. Social interaction of an amiable kind involved primarily head rubbing, and to a less extent forms of body contact, such as mutual grooming. Often heard in the context of bringing two lions together was a

special sound -- the 'syndetic call'. Threat behaviour was a complex graded system employing a great variety of signals, many previously described by Leyhausen (1956) for small cats.

Mating occurred at any time of year, whereas young tended to be born in the first half of the year. Many of the matings did not result in conception.

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# APPENDIX

## LION RECORDS SINCE 1781

| Date | Location | Evidence | Reference |
|---|---|---|---|
| **AFGHANISTAN** | | | |
| 1888? | Kabul | Lions very rare, but said to be in hills near Kabul | Anon (1888) |
| 1920 | Afghanistan | Kinnear could find no reference | Kinnear (1920) |
| **ARMENIA** | | | |
| 1852 | Armenia | Chopin reported only seeing tigers, where lions were earlier seen | Vereshchagin (1967) |
| **INDIA** | | | |
| 1781 | Sabermatti River, near Cambay | Durlee described hunting four lions | Forbes (1834a) |
| 1813 | Sabermatti River, near Cambay | Forbes saw a skin of a lioness taken in area | Forbes (1834b) |
| 1814 | Hurriana, south of Cuggar | Major Brown reported that lions had become extinct | Anon (1888) |
| 1814 | Palamaw district, Behar and Orissa states | One lion reported killed | Kinnear (1920) |
| 1814? | Narbada | Southern most limit | Kinnear (1920) |
| 1814? | Malwa Province | Jahangir recorded killing several | Anon (1888) |
| 1814? | Malwa Province | Rev. Terry took precautions against lions | Anon (1888) |
| 1820? | Runn of Kutch | Col. Benbow hunted lions on horseback | Anon (1888) |
| 1820? | Barah jungles | Lions exist | Anon (1888) |
| 1825 | Saharunpur district | Heber reported that lions common | Anon (1888) |
| 1825 | Ludhiana district | Heber reported that lions common | Anon (1888) |
| 1825 | Rohilkhand | Heber stated lions were killed | Anon (1888) |
| 1825 | Moradabad | Heber stated lions were killed | Anon (1888) |
| 1825 | Rampur | Heber stated lions were killed | Anon (1888) |

| | | | |
|---|---|---|---|
| 1829 | Gir forest | Col. Faunthorpe collected three lions for British museum | Pocock (1930) |
| 1832? | Gwalior | Fairly considerable numbers | Fenton (1908) |
| 1832? | Goona | Fairly considerable numbers | Fenton (1908) |
| 1832? | Saugor | Fairly considerable numbers | Fenton (1908) |
| 1832? | Khandeish | Fairly considerable numbers | Fenton (1908) |
| 1832? | Jhansi | Fairly considerable numbers | Fenton (1908) |
| 1832? | Allahabad | Fairly considerable numbers | Fenton (1908) |
| 1832? | Mount Abu | A favourite locality | Fenton (1908) |
| 1832 | Deesa | Hunted by 23rd Bombay Cavalry | Fenton (1908) |
| 1832? | Ahmedabad, Sabarmatti river and edge of Runn | A favourite locality | Fenton (1908) |
| 1832 | Baroda | One killed | Kinnear (1920) |
| 1832-33 | Rajkot | Capt. Reeves and others hunted lions on horseback | Anon (1888) |
| 1834 | Punjab | Became extinct | Daniel (1956) |
| 1834 | Bihar | Became extinct | Daniel (1956) |
| 1835 | Junjuwara | Major Fulljames turned out lion | Anon (1888) |
| 1836 | Ahmedabad | Comparatively common | Kinnear (1920) |
| 1837 | Saugay, Central Prov. | Dr. Spry obtained lion skin | Vernay (1930) |
| 1837-64 | Central Province | Numerous records | Vernay (1930) |
| 1842 | Sind | Became extinct | Daniel (1956) |
| 1842 | Hurriana | Edward Blyth reported lion extinct | Kinnear (1920) |
| 1845 | Sind | Cub collected for Calcutta zoo | Anon (1888) |
| 1845 | South of Gwalior | Lion collected for London zoo | Anon (1888) |
| 1847 | Sind River, in Kotah | Edward Blyth reported a few remaining | Kinnear (1920) |
| 1847-48 | Rhyl in Damoh district | Edward Blyth reported a female killed | Kinnear (1920) |
| 1851 | Sagar district | Lion killed | Anon (1888) |
| 1856-58 | Delhi district | Col. Smith killed 50 lions | Kinnear (1920) |
| 1860? | Jubbulpur-Allahabad railway | Lion killed | Anon (1888) |
| 1862 | Deesa | Times of India correspondent reported lions exist | Anon (1888) |
| 1863 | Patulghar | Col. Martin and Mr. Beadon saw eight lions | Kinnear (1920) |

| | | | |
|---|---|---|---|
| 1863 | Sind River, in Kotah | Edward Blyth reported that lion was extinct | Kinnear (1920) |
| 1864 | Saugay, Central Prov. | Shikharis reported seeing a large cat without stripes | Vernay (1930) |
| 1864 | Deesa | Lt. Clarke badly mauled by a lioness | Kinnear (1920) |
| 1864 | Sheorajpur | Police wounded a lion | Kinnear (1920) |
| 1865 | Gwalior | Three officers shot two of three lions seen | Kinnear (1920) |
| 1866 | 80th mile stone on Jubbulpur-Allahabad railway | Messrs. Lovell and Kelsay shot a lion | Kinnear (1920) |
| 1866 | Kotah | One party shot 9 lions | Kinnear (1920) |
| 1867 | Goona | Two or three lions shot | Kinnear (1920) |
| 1867 | Gwalior | Blanford reported lion scarce | Kinnear (1920) |
| 1867 | Kotah | Blanford reported lion still existed | Kinnear (1920) |
| 1867 | Deesa | Blanford reported lion still existed | Kinnear (1920) |
| 1867 | Mt. Abu | Blanford reported lion still existed | Kinnear (1920) |
| 1867 | Ahmedabad | Blanford reported lion still existed | Kinnear (1920) |
| 1867 | Bundelkund | Blanford reported occasional occurrence | Kinnear (1920) |
| 1868 | Deesa | Col. Heyland shot last lion outside Kathiawar | Fenton (1908) |
| 1868 | Barda Hills | Some lingered for a while | Fenton (1908) |
| 1868 | Aleche Hills | Some lingered for a while | Fenton (1908) |
| 1868 | Chotila | Some lingered for a while | Fenton (1908) |
| 1868 | Dhrangadhra | Some lingered for a while | Fenton (1908) |
| 1868 | Jasdan | Some lingered for a while | Fenton (1908) |
| 1868 | Dhank | Forest isolated by cultivation resulting in lions deserting the area | Fenton (1908) |
| 1868 | Chorwar | Lions deserted because area isolated by cultivation | Fenton (1908) |
| 1871 | Laliput | Blanford says a few still exist | Guggisberg (1963) |
| 1872 | Cheenhill 9 miles from Goona | Sir Gerard killed a lion | Kinnear (192 |
| 1872 | Mt. Abu | Shikari killed lion | Kinnear (19 |
| 1872 | Jodhpur | Last four reported shot | Kinnear (19 |

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|---|---|---|---|
| 1872 | Central India | Became extinct | Daniel (1956) |
| 1873 | Central India | Col. Hall killed last lion | Kinnear (1920) |
| 1878 | Deesa | Col. Nurse reported last killed | Kinnear (1920) |
| 1880 | Palanpur | Palanpur Gazetteer reported lion rare | Kinnear (1920) |
| 1888 | Gujarat | Last four killed in Gujarat outside Kathiawar | Lydekker (1924) |
| 1891 | Jodhpur | Blanford reported that Guggisberg probably a few remained | (1963) |
| 1891 | Oodeypur | Blanford reported that Guggisberg probably a few remained | (1963) |
| 1891 | Mt. Abu | Blanford reported that Guggisberg probably a few remained | (1963) |

IRAN

| | | | |
|---|---|---|---|
| 1785 | Iran | Not numerous and diminishing | Martyn (1785) |
| 1841 | near Qalehtul | One male killed | Layard (1887) |
| 1841 | Hills near Shushtar | Lion killed man | Layard (1887) |
| 1841 | near Qalehtul | Several lions seen in vicinity | Layard (1887) |
| 1841 | Halaugon | Lioness killed | Layard (1887) |
| 1841 | Ram Hormuz | Lions abounded | Layard (1887) |
| 1841 | Banks of Karun River | Lions abounded | Layard (1887) |
| 1841 | Foot of Lur mountains | Sometimes lions ascended | Layard (1887) |
| 1841 | Between Hawizah and Nashwar | Saw lion | Layard (1887) |
| 1842 | 7 miles south of Shuster on Karun River | Saw male lion | Layard (1887) |
| 1842 | 13 miles south of Dizful | Saw three lions swimming river | Layard (1887) |
| 1842 | Rivers in Khuzistan | Lions commonly seen | Layard (1887) |
| 1842? | Mt. Asemari in Khuzistan | Lion killed and reported by Layard | Kinnear (1920) |
| 1849-50 | Susa near Dizful | Loftus reported lions found there | Kinnear (1920) |
| 1850 | Duzdab near Baluch-Persian border | People in area refer to lions being there 70 years before when visited by Capt. Heaney in 1920 | Champion-Jones (1945) |
| 1870-71 | Dashtiarjan | Sir Oliver St. John referred to four or five lionsbeing shot here annually | Guggisberg (1963) |

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|---|---|---|---|
| 1875 | Karun | Mr. Robertson referred to lions being plentiful | Kinnear (1920) |
| 1876 | Iranian tableland | Lion did not exist anywhere | Guggisberg (1963) |
| 1876 | western flanks of Zagros mountains | Lion occurred reported Blanford | Guggisberg (1963) |
| 1876 | south and southeast of Shiraz | Lion occurred reported Blanford | Guggisberg (1963) |
| 1876 | plains of Susiana | Lions occurred reported Sir Oliver | Kinnear (1920) |
| 1890 | between Fellahi and River Kurun | Col. Burton saw lion tracks | Guggisberg (1963) |
| 1890 | River Karak near Susa | Col. Burton saw tracks of lioness with cubs | Guggisberg (1963) |
| 1891 | lower part of Karun R. | Sir Alfred Pease reported that lion was still found | Kinnear (1920) |
| 1897 | Pusht-i-Kuh mountains | Col. Burton told that lions still existed | Guggisberg (1963) |
| 1900 | Kazerun | Sir Percy Sykes reported that lions existed | Kinnear (1920) |
| 1906 | Karun | Hubbard reported last lion seen | Kinnear (1920) |
| 1908 | Road from Ahwaz | Sir Arnold Wilson saw a lion, referred to De Morgan and Lorimer often hearing that a few remain | Guggisberg (1963) |
| 1910 | Karan River | Sir Percy Sykes saw body of a lion floating in river | Kinnear (1920) |
| 1918-19 | Pusht-i-Kuh | Gillan saw skin of lioness | Gillan (1951) |
| 1920 | Karun | Expeditionary forces found no lions | Kinnear (1920) |
| 1921 | Jebel Hamrin | Saw lioness with two cubs, and photographed tracks | Griffiths (1952) |
| 1922 | Pusht-i-Kuh | Wali of Pusht-i-Kuh and son saw a lion | Griffiths (1952) |
| 1923 | south of Shiraz | A lion killed | Guggisberg (1963) |
| 1928 | southern Persia | French and English engineers observe a pair of lions for sevefal days | Guggisberg (1963) |
| 1929 | near Dizful | American engineers saw a pair of lions | Guggisberg (1963) |
| 1941 | Kharki River | Lion seen by Jones and another officer | Champion-Jones (1945) |
| 1942 | 40 miles northwest of Dizful | Lion seen by seven men of the Indian Field Survey Company along with three policemen | Heaney (1943) |

IRAQ

| | | | |
|---|---|---|---|
| 1785 | Iraq | Not numerous and diminishing | Martyn (1785) |
| 1802 | Bussorah | Oliver saw five lions in a Baghdad menagerie caught five years earlier (1802) | Pocock (1930) |
| 1817 | Birs Nimrod | Sir Robert Porter saw three lions | Guggisberg (1963) |
| 1820-21 | Jat (Zab) River (east of Mosul) | Rich saw no lions, but heard they were common | Kinnear (1920) |
| 1820-21 | Junction of Tigris and Hye (Shatel Hie?) | Rich saw coffin of child said to have been killed by a lion | Kinnear (1920) |
| 1820-21 | Tigris river below Kut | Rich heard lions roaring | Kinnear (1920) |
| 1830 | Bussorah | Pair of cubs sent to London zoo | Pocock (1930) |
| 1830 | Euphrates river above Hit | Col. Chesney saw a lion and heard several roaring | Kinnear (1920) |
| 1835-36 | Euphrates river below Ctesiphon | Asst. surgeon Winchester saw three lions. Tried to shoot them | Kinnear (1920) |
| 1835-36 | Kut | Ainsworth found natives afraid of lions in this area | Kinnear (1920) |
| 1835-36 | Central Khaldeaea | Ainsworth saw many lions | Kinnear (1920) |
| 1835-36 | Baghdad | Ainsworth saw a tame lion | Kinnear (1920) |
| 1840 | near Mosul | Layard lit fires to keep away lions said to be frequenting area | Kinnear (1920) |
| 1848-49 | Niffer marshes | Many lions are seen Wild boar numerous | Layard (1853) |
| 1848-49 | Hillah | Layard saw two locally caught lions | Layard (1853) |
| 1848-49 | Kabour river | Layard saw a boy who had been attacked by a lion | Layard (1853) |
| 1849 | Tigris below Baghdad | Layard reported that lions were common below Baghdad, but rarely above | Guggisberg (1963) |
| 1849 | Hindeyah marshes | Layard saw cub caught by Arab | Kinnear (1920) |
| 1848-49 | Sinjar river | Layard heard of Arabs frequently catching lions | Guggisberg (1963) |

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|---|---|---|---|
| 1850s | Warka (Wurka?) | Loftus had his camp disturbed nightly by lions | Guggisberg (1963) |
| 1850s | Mosul | Rose reported [illegible] lions in vicinity | Guggisberg (1963) |
| 1856 | Babylon | Pocock reported that a cub from this region was presented to London zoo | Pocock (1930) |
| 1861 | mouth of river Tigris | Capt. Balfour saw a total of 17 lions in one day | Anon (1888) |
| 1876 | reedy swamps bordering Tigris and Euphrates | Oliver reported that lions were very numerous | Kinnear (1920) |
| 1876 | Mesopotamia | Blanford reported that lions existed | Guggisberg (1963) |
| 1888 | Lower mesopotamia | Dr Moril reported lions still numerous | Kinnear (1920) |
| 1891 | Euphrates | Sir Alfred Pease reported that lions still existed | Kinnear (1920) |
| 1897 | Mema and Tigris river junction | Col. Burton reported that lions existed there | Guggisberg (1963) |
| 1907 | Mesopotamia | Lion said to have come from this region presented to Berlin Zoological Gardens | Kinnear (1920) |
| 1914 | Khabur river | Miss Bell reported that Turkish Governor had two lions at Mosul taken from Khabur river | Gillan (1951) |
| 1917 | Tigris and Euphrates | Four years in the area led Gillan to believe that lions were extinct | Gillan (1951) |
| 1920 | Kabur river | Expeditionary Forces asked to report any sightings. None were received | Kinnear (1920) |

PAKISTAN

| | | | |
|---|---|---|---|
| 1810 | Kot Deji | Date of last lion shot | Kinnear (1920) |
| 1810? | Bahawalpur | Lions formerly found there | Kinnear (1920) |
| 1830 | Bela, in Runn of Kutch | Lion shot; possibly a straggler from Gujarat | Kinnear (1920) |

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|---|---|---|---|
| 1921 | Bolan pass | Admiral Dumas and two ladies, reported seeing a possible lion | Pocock (1936) |
| SYRIA | | | |
| 1880? | Damascus | Tristam reported in 1884 that a few years earlier a dead lion was brought to Damascus | Guggisberg (1963) |
| 1891 | west of Aleppo | Sir Alfred Pease reported that lions still existed | Kinnear (1920) |
| TURKEY | | | |
| 1785 | Turkey | Not numerous and diminishing | Martyn (1785) |
| U.S.S.R. | | | |
| 1888? | Tashkend | Lions said to be found as far north as Tashkend | Anon (1888) |